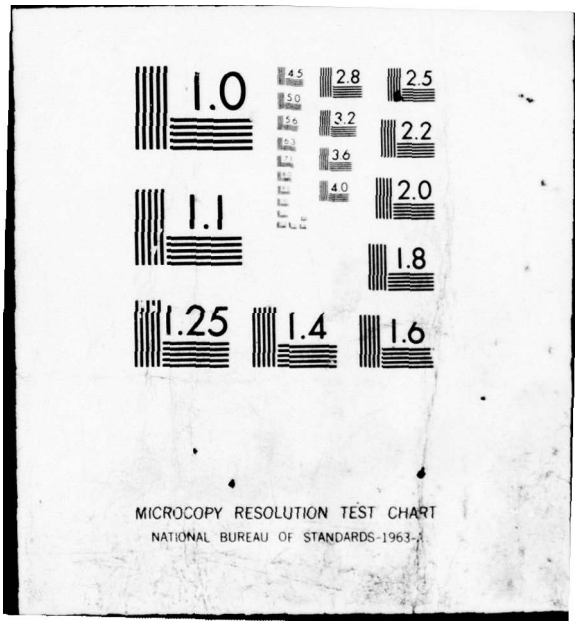
AD-A070 361 NAVAL RESEARCH LAB WASHINGTON DC F/G 20/4
ADINC: AN IMPLICIT LAGRANGIAN HYDRODYNAMICS CODE.(U)
JUN 79 J P BORIS
UNCLASSIFIED NRL-MR-4022 NL

1 OF 2
AD A070361


1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0
4.5
5.0
5.6
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

LEVEL II

NRL Memorandum Report 4022

ADINC: An Implicit Lagrangian Hydrodynamics Code

J. P. Boris

Laboratory for Computational Physics

June 15, 1979

This work was supported by the Office of Naval Research under Project No. R0110941

NAVAL RESEARCH LABORATORY
Washington, D.C.

DISCLAIMER NOTICE

THIS DOCUMENT IS BEST QUALITY PRACTICABLE. THE COPY FURNISHED TO DDC CONTAINED A SIGNIFICANT NUMBER OF PAGES WHICH DO NOT REPRODUCE LEGIBLY.

SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: NRL Memorandum Report 4022
2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)*: ADINC: AN IMPLICIT LAGRANGIAN HYDRODYNAMICS CODE
5. TYPE OF REPORT & PERIOD COVERED: Interim Report
6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): Jay P. Boris
8. CONTRACT OR GRANT NUMBER(s): Memorandum rept.
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Naval Research Laboratory, Washington, DC 20375
10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: Project No. RR0110941, Program Element 61153N, NRL J.O. 62H02-51
11. CONTROLLING OFFICE NAME AND ADDRESS: Office of Naval Research, 800 N. Quincy Street, Arlington, VA 22203
12. REPORT DATE: June [redacted] 79
13. NUMBER OF PAGES: 148
14. MONITORING AGENCY NAME & ADDRESS *(if different from Controlling Office)*: 150p.
15. SECURITY CLASS. *(of this report)*: UNCLASSIFIED
15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT *(of this Report)*

Approved for public release; distribution unlimited

NRL-MR-4022

17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*

RR011 09 RR011 0941

18. SUPPLEMENTARY NOTES

This work was supported by the Office of Naval Research under Project No. RR0110941.

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Multifluid computation
Lagrangian hydrodynamics
Implicit fluid dynamics

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

This paper presents and describes a new software package called ADINC (ADiabatic and INCompressible flows) which is designed to solve the mass, momentum, and adiabatic energy equations for a rather general one-dimensional fluid system. A fully Lagrangian, conservative hydrodynamics algorithm is incorporated so that interfaces between different materials can be followed accurately. The Courant timestep limit for sound waves is overcome by implicit time differencing with a quadratically convergent iteration for nonlinear time centering. Listings of the pertinent ADINC routines and a general driver test program are included in the appendices.

(Continued) over

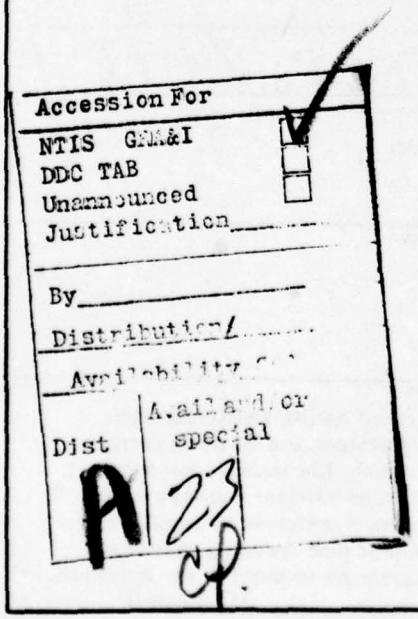
DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE
S/N 0102-014-6601

SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

251 950

20. ABSTRACT (Continued):

A rather general analytic equation of state routine is included which handles adiabatic gases, slightly compressible solids, and even the incompressible limit in adjacent cells. The test program has provision for up to five layers of material. Three test problems are presented in the appendices with representative outputs for code verification.



CONTENTS

Symbol Table

r_i = RAD(I)	= position (cm) of the i-th cell interface
V_i = VEL(I)	= velocity (cm/sec) of the i-th cell interface
ρ_i = RHO(I)	= density (gm/cc) of the fluid in the i-th cell between interfaces $i-1$ and i
P_i = PRE(I)	= pressure (erg/cc) of the fluid in the i-th cell
t	= time variable (sec)
r	= generalized 1D coordinate (cm)
$\rho(r,t)$	= fluid density as a continuum function
$V(r,t)$	= fluid velocity as a continuum function
$P(r,t)$	= fluid pressure as a continuum function
$\rho_c(r)$	= density at zero pressure, a Lagrangian fluid property
$S(r)$	= entropy constant, a Lagrangian fluid property
$\gamma(r)$	= adiabatic gas constant, a Lagrangian fluid property
Λ	= cell volume
$A(r)$	= cross sectional area of the 1D computational "volume" as a function of position
$V(r)$	= used briefly (Section II) as an integrated volume variable, do not confuse with velocity
α = ALPHA	= 1,2,3, or 4 to determine ADIWC geometry
$G_1, \ldots, G_5$ = GEOMCO	= geometry coefficients for power series coordinates
N	= # of fluid cells in the computational domain
Λ_i = LAMC(I)	= volume (cm^3 = cc) of the i-th cell
A_i = AREA(I)	= area (cm^2) of interface i
R_i = RADC(I)	= cell i center location (cm)
r_L = RLNEW	= left bounding interface location (cm)
r_R = RRNEW	= right bounding interface location (cm)

V_L = VLNEW	= left boundary interface velocity (cm/sec)
V_R = VRNEW	= right boundary interface velocity (cm/sec)
δt = DT,DTIN	= computational timestep increment (sec)
ϵ_r = EPSR	= explicitness parameter, position equation
ϵ_v = EPSV	= explicitness parameter, momentum equation
o	= old value, as a superscript
n	= new value, as a superscript
p	= most recent approximation to the new value, as a superscript
$<p\delta r>_{i+1/2}$	= average mass per unit area (gm/cm^2) in the vicinity of interface i
P_i^*	= special acceleration averaged pressure at interface i
h	= value averaged at the new and old values, as a superscript
a_i, b_i	= coefficients in the momentum Eq. (13) and following
$\Lambda_i^{n(eos)}$ = LAMEOS(I)	= estimated new volume of cell i using the equation of state, should equal r
$\Lambda_i^{n(fd)}$	= estimated new volume of cell i using the fluid dynamic motion
S_i = ENTC(I)	= entropy constant (erg/cc) of cell i
$\left[\frac{\partial \Lambda}{\partial P}\right]_i^{P(eos)}$ = DLAMDP(I)	= rate of change of cell i volume with pressure from the equation of state.
d_i^+, d_i^-, c_i	= coefficients in Eq. (18) and following
A_i^*, B_i^*, C_i^*, D_i^*	= coefficients in the tridiagonal equation derived for $\{P_i^n\}$, Eq. (22).
ΔM_i = MASSC(I)	= fluid mass (gm) in cell i
C_s	= sound speed in the fluid
δt_{val} = DTVAL	= timestep limit (sec) to prevent interface crossing
δt_{max} = DTMAX	= the maximum timestep (sec) permitted in the

	calculation, chosen by the user
$\delta t_{\min}$ = DTMAX	=the minimum timestep (sec) permitted in the calculation, chosen by the user
γ_i = GAMMAC(I)	=adiabatic gas constant, a Lagrangian fluid property of cell i
δV = DVEL	=velocity perturbation (cm/sec) in standard Test #1, Eq. (28), and following
E_{therm_i} = ETHERM(I)	=internal energy density (erg/cc) in cell i
Λ_i^+, Λ_i^-	=partial volumes of cell i (cm ^{3})
E_{RINEI} = EKINE(I)	=kinetic energy density in cell i (erg/cm^3)
k	=wavenumber cm^{-1}) in Eq. (35)
M_s, p_s, V_s	=slug mass, density and velocity in standard Test # 2, a nearly incompressible fluid
$P_R(t)$, $P_L(t)$	=pressure in the gas rgions to the right and left of the slug respectively
γ_R, γ_L	=adiabatic gas constants in the regions to the right and left of the heavy slug
$W_R(t)$, $W_L(t)$	=width (cm) of the gas regions to the right and left of the slug
S_R, S_L	=entropy constant in the gas regions to the right and left of the slug
ω	=angular frequency of slug oscillation
M_R, M_L	=mass (gm) of the gas regions to the right and left of the slug.
L_c	=the size (cm) of the system when $\rho = \rho_c$
T	=nonlinear limiting period (sec) of the oscillating slug

ADINC: An Implicit Lagrangian Hydrodynamics Code

I. INTRODUCTION

This paper presents and describes a new software package called ADINC (ADiabatic and INCompressible flows) which is designed to solve the mass, momentum, and adiabatic energy equations for a rather general one-dimensional fluid system. To permit accurate representation of material interfaces, a fully conservative, Lagrangian hydrodynamics algorithm has been incorporated. Implicit time differing with a quadratically convergent iteration for non-linear time centering permits ADINC to take long timesteps exceeding the Courant sound speed limit. ADINC is designed as a user-oriented package with a flexible equation of state which may vary from cell to cell and provision for four different geometries. This write-up not only describes the techniques employed and three different benchmark test problems, it serves as documentation for the package. To these ends, listings and representative outputs are included in the appendices.

ADINC was written to circument in a single software package a number of common numerical dificulties which arise in the simulation of many different fluid dynamic systems. In some fluids the physical phenomena under study vary slowly compared to the time it takes sound waves to cross the system. Nevertheless, substantial compressions and expansions occur so the incompressibility assumption is invalid. In other systems rather sharp interfaces between chemical species or between different temperature regions must be maintained, yet the fluids interact dynamically across the interface.

The first class of problems demands an implicit treatment of sound waves in general although the asymptotic "slow-flow" approach[1-3] works well in many cases. In many combustion systems, for example, heat is being added slowly so the gas expands locally where the heat is being released. The expansion is so structured that it guarantees continued spatial constancy

*Manuscript submitted April 20, 1979.

of the pressure. Such pressure fluctuations as do occur[4] are consistent with driving the fluid flows which bring about the required expansion. In these slow flow systems the heating and cooling rates from chemical reactions, thermal diffusion, and radiation emission and absorption control the hydrodynamics and hence determine the local density and temperature. The pressure evolution equation can be solved algebraically for the divergence of the velocity at any instant of time while the vorticity evolution equation is integrated to advance the curl of the velocity.[5] Given the curl, the divergence, and reasonable boundary conditions, almost everything we need to know about the flow is known. When the pressure fluctuations, i.e. the sound waves, themselves are required, a stiff, implicit hyperbolic wave equation results. Such equations can be solved numerically but in multidimensions the cost is often high and the best formalism is by no means clear.

In the study of ablation and deflagration phenomena, pressure variations are important even though the fluid profiles themselves vary slowly. Here again the sound speed in the high temperature region would require very small timesteps if an explicit integration algorithm is used. Even though the slow-flow approximation of constant pressure is not valid here, the generalization to implicit hydrodynamics is valid— as long as shocks are absent. In atmospheric flows, in turbulence modelling for reactive systems and in studies of Rayleigh-Taylor instabilities it is the pressure fluctuation gradients specifically which interact with the local density gradients to generate vorticity. Thus, again, some form of implicit hydrodynamics or implicit pressure solution is required in these and similar cases.

In imploding liner and pellet fluid dynamics, solid and higher density "fluids" such as compressed DT, heavy pusher shells, and liquid metal rotating liners move in a way which is often shock free and which generally requires non-trivial equations of state. In LINUS[6-8], for example, an electrically conducting cylindrical liquid metal shell is imploded to compress a fusion plasma. The material along the inner surface of the liner starts out almost perfectly imcompressible but compresses by as much as 50% when the dynamic pressure from geometric

convergence reaches its maximum. The liquid compression is important and hence so are the detailed dynamics leading up to that compression. The sound waves in the liquid metal lead to a "water hammer" effect[7,8] which may have severe engineering consequences.

The second class of numerical problems, maintaining sharp interfaces between disparate materials or between materials in widely disparate states, often demands a Lagrangian description so that the exact interface location is available at any time. Eulerian computations end up with the real interface spread over several zones from the numerical diffusion needed for stability. While this numerical smearing of gradients is acceptable in many cases, in many others it is not acceptable. The ADINC package uses an implicit, fully Lagrangian algorithm to overcome these two classes of problems. The system as currently modelled is assumed to have no non-ideal effects such as viscosity. Thus energy conserving shocks are not recovered even though large amplitude acoustic waves are handled accurately. The entire package is structured so that rather general equations of state, boundary conditions, and flow geometry are permitted. Other non-ideal effects can be introduced to the calculation via time-step splitting.

The Courant timestep limit is overcome by using an implicit finite difference algorithm with adjustable explicitness coefficients in both the position and velocity equations. Since the basic equations (Section II) are nonlinear, iteration is required to obtain convergence. ADINC, unlike some implicit formulations, continually re-evaluates the nonlinear terms after each iteration to obtain an accurate as well as a stable algorithm when changes per timestep are large. Since this increased accuracy has the computational penalty that all coefficients for the iteration must be re-evaluated each iteration cycle, care has been taken to develop a quadratically convergent iteration encompassing both fluid dynamics and equation of state variations simultaneously.

The interface resolution problem is handled by making the calculation fully Lagrangian. No rezone or remap capability is included in the basic package so numerical diffusion from spatial differences is absent from the model. Future additions to the ADINC package will include

a fully Lagrangian adaptive gridding package so that adequate resolution can be maintained in regions where sharp gradients develop or where zone sizes become unacceptably large due to fluid expansion.

Section II of this paper discusses the basic dynamical equations solved by the ADINC package and the various choices of geometry which are available. Section III presents the numerical algorithms used to integrate these equations along with the various tricks implemented to maintain accuracy in bizarre situations. The timestep conditions built into the package are also discussed.

Section IV is devoted to the structure of the ADINC package and reviews the three major routines. It gives calling sequences and argument lists for the nine entries. ADINC has been constructed as a utility package to advance the four hydrodynamic variables:

r_i = position (cm) of the i-th cell interface

V_i = velocity (cm/sec) of the i-th all interface

ρ_i = density (gm/cm^3) in the i-th cell between interfaces i-1 and i, and

P_i = pressure (erg/cm^3) in the i-th cell between interface i-1 and i.

ADINC has been cast into a form resembling that of an ordinary differential equations package. The user requests integration of the system of equations to a certain point in time and ADINC then selects the number and length of timesteps necessary to span this interval. The user also has control of various error and integration parameters without having to modify the ADINC code.

Section V tells how to use ADINC but a prospective user will probably find Section VI which describes three test problems and the Appendices equally instructive. The three test problems were designed to give a prospective user a useful background of experience with the program in different regimes and with different problems. The Appendices contain listings of

the ADINC package (Appendix A) and a rather general test program with initialization and I/O routines (Appendix B). The present version of ADINC and its test program are written entirely in 64 bit floating point arithmetic. Thus convergence to better than 1 part in 10^7 is possible for problems with near incompressibility and/or extreme density discontinuities which require this accuracy. A quadratically convergent algorithm is used to speed joint convergence of the nonlinear fluid dynamics and equation of state physics. The only portion of the code not appearing in the appendices are the vectorized tridiagonal solvers and these are documented by Boris in NRL Memorandum Report 3408, November, 1976.

The test program is arranged to handle up to five distinct layers of fluid composed of up to 200 individual finite difference cells. Problems in one of four geometries can be set up: Cartesian coordinates, cylindrical coordinates, spherical coordinates, and a variable power series coordinates for treating one-dimensional nozzle-like geometries. The boundary conditions are controlled by specifying the position and velocity of the first and the last cell interface. Piston-like conditions coupling the fluid system to external sources and sinks of energy are easy to set up.

Appendices C, D, and E reprint actual output from the three test problems for code verification and illustration purposes. ADINC has been optimized and vectorized for the Texas Instruments' ASC system at NRL.

II. THE BASIC EQUATIONS

ADINC solves the following equations for mass and momentum transport in one dimension:

$$\frac{d\rho}{dt} = -\rho \nabla \cdot \mathbf{V} \tag{1}$$

and

$$\rho \frac{d\mathbf{V}}{dt} = -\nabla P. \tag{2}$$

The energy evolution equation is eliminated by using an adiabatic equation of state in which the entropy is assumed constant throughout the numerical integration. Non-adiabatic processes such as external heating, thermal conduction, and chemical energy release can be added to Eqs. (1-2) using time step splitting provided sufficiently short timesteps are used to make the splitting procedure accurate. In the reference version of ADINC, reproduced as Appendix A of this report, the equation of state of the fluid in each cell of the calculation is

$$\rho(P, S, \ldots) = \rho_c + (P/S)^{1/\gamma}. \tag{3}$$

This equation of state with $\rho_c = 0$ is correct for adiabatic compression and expansion of an ideal gas. In that case $1.2 \lesssim \gamma \lesssim 1.7$. When $\rho_c \neq 0$, Eq. (3) gives an adequate representation of a mildly compressible liquid. Water, for example, has $\rho_c = 1$ gm/cc and $S \approx 2.5 \times 10^{11}$ in CGS units. Thus in this crude model a pressure of 250 Kbar (2.5×10^{11} dynes/cm^2) causes a substantial increase in the compression.

During an ADINC timestep ρ_c, γ, and S are treated as constants; only the variation of ρ with P is considered. ADINC does not use the temperature T anywhere and uses Eq. (3) in the form specified. Rather than knowing ρ and asking what the pressure is, ADINC calculates the fluid density given an approximation to the pressure. This equation of state density is compared to the density derived from the fluid dynamics via Eq. (1). This difference is iterated to zero using a quadratically convergent implicit solution of Eq. (2) which delivers an improved pressure approximation. During this iteration the analytic derivative $\frac{d\Lambda}{dP}$ is used where Λ is

the volume of a computational cell.

$$\frac{1}{\Lambda}\frac{d\Lambda}{dP} = -\frac{1}{\gamma\rho P}(P/S)^{1/\gamma} \tag{3'}$$

for the particular equation of state (3).

The ADINC package is written in a sufficiently modular form that replacement of Eq. (3) with another equation of state should be quite straight forward. To do this the common block /ADICOM/ would have to be modified to include other constants of the fluid motion for the various materials being represented. Thermochemistry and thermophysical properties of realistic gases could be included, for example, so the effective gas constant γ can be made to display the correct variation with T. As another example, more involved equations of state for solid and liquid materials can be included. We plan to use Gardner's model[9] in studies where the transition from solid to plasma must be treated accurately.

ADINC uses the equation of state in the form $\rho(P, S, \ldots)$ because the density is a much less sensitive function of the pressure than the pressure is of the density for liquids and solids. During the iteration process, finite errors in pressure and density are expected. In the other form $P(\rho, S, \ldots)$, the errors in density ρ would appear as wild fluctuations in the pressure. For gases and plasma the two forms are basically of the same accuracy. There is a second related reason why ADINC uses the equation of state in the case $\rho(P, S, \ldots)$, a specific form of which appears in Eq. (3). The ADINC package is specially designed to deal with discontinuities in zone size and density. When a gas-solid interface is encountered, the pressure is continuous but the density need not be. Therefore finite differences in the pressure are bound to be more accurate than transfomed differences in the density.

Equations (1-3) are solved in the form shown without non-dimensionalization or scaling. The package is designed with CGS units in mind but these appear nowhere explicitly in the calculation. Therefore non-dimensional calculations are possible without modifying the program but *caveat emptor.*

To complete the basic equations of the system, the geometry of the calculation must be given. ADINC, as presented, allows four one-dimensional systems to be treated by selection of the integer α. Figure 1 shows a general one-dimensional region of variable cross section area $A(r)$. The volume of the region is $V(r) = \int_{r_1}^{r} A(r')\, dr'$. The numerical algorithm, discussed in the next section, uses interface areas and cell volumes exclusively to convey geometry information. Therefore substitution of other 1D geometries than those provided for should be straightforward,

α = 1, Cartesian coordinates

$$\left.\begin{aligned} A(r) &= 1.0 \\ V(r) &= r \end{aligned}\right\} \tag{4.1}$$

α = 2, Cylindrical coordinates

$$\left.\begin{aligned} A(r) &= 2\pi r \\ V(r) &= \pi r^2 \end{aligned}\right\} \tag{4.2}$$

α = 3, Spherical coordinates

$$\left.\begin{aligned} A(r) &= 4\pi r^2 \\ V(r) &= \frac{4}{3}\,\pi r^3 \end{aligned}\right\} \tag{4.3}$$

α = 4, Power series (nozzle) coordinates

$$\left.\begin{aligned} A(r) &= G_1 + G_2 r + G_3 r^2 + G_4 r^3 + G_5 r^3 \\ V(r) &= G_1 r + G_2 \frac{r^2}{2} + G_3 \frac{r^3}{3} + G_4 \frac{r^4}{4} + G_5 \frac{r^5}{5} \end{aligned}\right\} \tag{4.4}$$

In principle the volume is ambiguous up to an additive constant, the volume $V(r_1)$. In practice ADINC deals only with volume differences to determine the incremental volume Λ of a computational cell so this constant cancels out conveniently. Using the symbol Λ also means that confusion with the velocity V cannot occur.

III. THE NUMERICAL ALGORITHM

Figure 1 shows a schematic diagram of the computational region treated by the ADINC package. There are N cells of volume Λ_i $(i = 2, 3, \ldots, N + 1)$ bounded by $N + 1$ interfaces of area A_i $(i = 1, \ldots, N+1)$. The interfaces are located at r_i $(i = 1, \ldots, N + 1)$ so $A_i \equiv A(r_i)$ where $A(r)$ is given by one of the choices $\alpha = 1, 2, 3, 4$ in Eq. (4). The cell volumes $\Lambda_i \equiv V(r_i) - V(r_{i-1})$ are the difference of the volume integral from Eq. (4) at the two cell interfaces. In the development to follow we will also need the cell center locations

$$R_i \equiv (A_i r_{i-1} + A_{i-1} r_i)/(A_i + A_{i-1})$$

which always lies between r_{i-1} and r_i provided the interface areas are positive.

In ADINC the first physical cell is $i = 2$ and it lies between interfaces r_1 and r_2. The last physical cell is $i = N + 1$ and lies between interfaces r_N and r_{N+1}. Cells 1 and $N + 2$ are not used currently by ADINC but have been left available for future use in complicated boundary conditions or extrapolations. Interface 1 is the left hand boundary of the system $(r_1 \equiv r_L)$ and interface $N + 1$ is the right hand boundary of the system $(r_{N+1} \equiv r_R)$. The interfaces are treated in a fully Lagrangian manner and therefore the interface velocities $\{V_i\}$ are defined as well as the interface positions $\{r_i\}$. The left hand boundary velocity $(V_L \equiv V_1)$ is established externally as is the right hand boundary velocity $(V_R \equiv V_1)$. The interior interface locations and velocities are the quantities which ADINC integrates from one discrete time t to the next $t + \delta t$ given the masses, entropies, and other cell quantities which are conserved during the motion.

The cell interface positions $\{r_i\}$ satisfy

$$\frac{dr_i}{dt} \equiv V_i \tag{5}$$

which has a straight forward discretization

$$r_i^n = r_i^o + \delta t[\epsilon_r V_i^o + (1 - \epsilon_r)\ V_i^n]. \tag{5'}$$

ADINC GRID STRUCTURE AND VARIABLE PLACEMENT

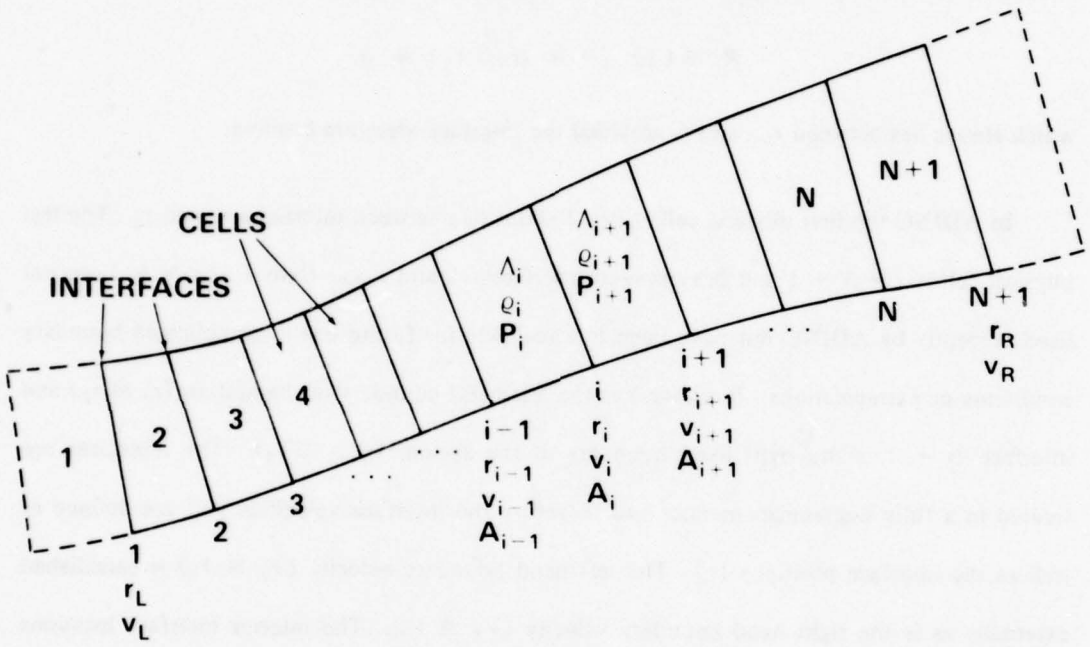


Figure 1 — Grid structure and variable definition for the ADINC package. Position r_i and Velocity V_i are defined at cell interfaces while density ρ_i and pressure P_i are defined at all centers. Interface area A_i and cell volume Λ_i are derived from the instantaneous interface positions $\{r_i\}$.

In Eq. (5′) and throughout the remainder of the paper the superscript "n" indicates variables at the "new" time $t + \delta t$ while superscript "o" indicates variables at the "old" time t. The quantity ϵ_r is the explicitness parameter for the interface position, $0 \leqslant \epsilon_r \leqslant 1$. When $\epsilon_r < 1$, the method is at least partially implicit. When $\epsilon = 1/2$ the method is centered and nominally most accurate. If long timesteps are comtemplated, $\epsilon \leqslant 1/2$ is required for Courant stability with strict inequality usually required to deal with nonlinear effects. When $\epsilon_r = 0$, the calculation is fully implicit, i.e. fully forward differenced. This case is most stable but is only first order accurate. ADINC uses the same value of ϵ_r at every interface but this one value is varied from cycle to cycle. Generalization to a spatially varying $\{\epsilon_{r_i}\}$ is quite possible but left for the future.

The momentum equation (2) for an interface velocity is as follows:

$$\frac{dV_i}{dt} \equiv \frac{-1}{\rho_{\text{interface } i}} \left.\frac{\partial P}{\partial r}\right|_{\text{interface } i} \tag{6}$$

where the density and pressure gradient are needed at cell interfaces. The discretization used in ADINC is

$$V_i^n = V_i^o - \frac{\delta t \epsilon_v}{<\rho\, \delta\, r>_{i+1/2}} (P_{i+1}^o - P_i^o) - \frac{\delta t (1 - \epsilon_v)}{<\rho \delta r>_{i+1/2}} (P_{i+1}^n - P_i^n) \tag{6′}$$

where ϵ_v is the explicitness parameter for the interface velocity and has the same properties described above for ϵ_r. The quantities ϵ_r and ϵ_v are distinct in ADINC but no reason has been uncovered to date for using different values in an actual calculation. The interface average indicated as $<\rho\, \delta\, r>_{i+1/2}$ is both a spatial and temporal average as described below. Physical considerations are used to define $<\rho \delta r>_{i+1/2}$ so the discretization in Eq. (6′) is insensitive to numerical errors arising from large density discontinuities at the interfaces.

Figure 2 shows two cells i and $i + 1$ which straddle interface i. The pressures P_i and P_{i+1} are defined at R_i and R_{i+1} as shown and the densities ρ_i and ρ_{i+1} are assumed constant throughout their respective cells. Because ρ_i and ρ_{i+1} differ spatially (ignore their time

ACCELERATION MATCHING ALGORITHM

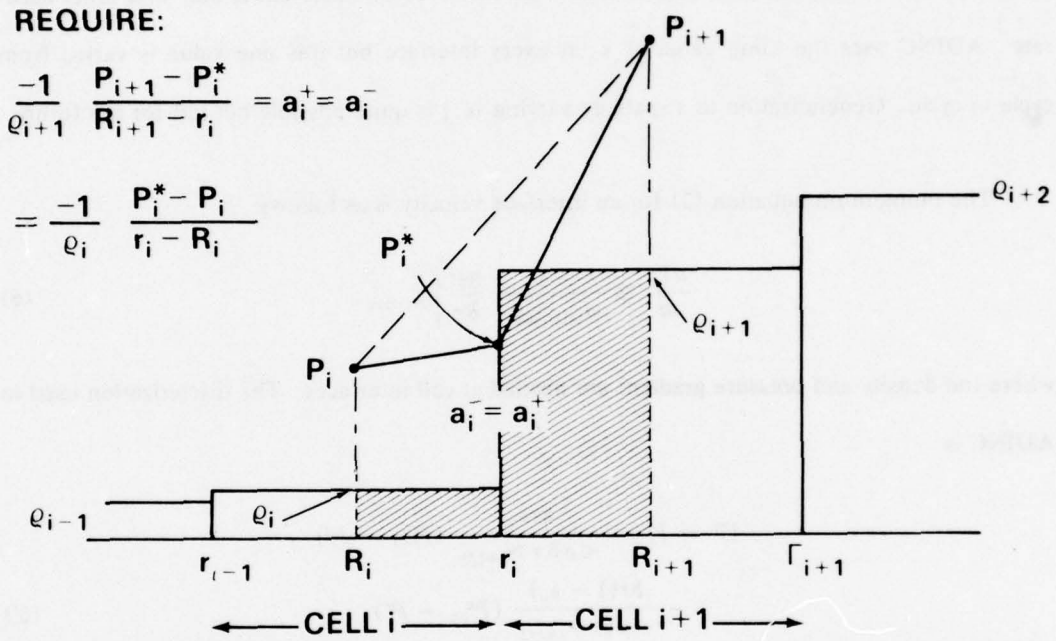


Figure 2 — Acceleration matching trick for density discontinuities at interfaces. An intermediate interface pressure P^* is defined such that the acceleration of material to the right and to the left of the interface is matched. Most the pressure gradient thus appears across the denser fluid.

variation for a moment), the straight line pressure gradient shown would impart a different acceleration to the fluid just to the right and to the left of interface i. If the fluid were permitted to move according to these distinct accelerations, the fluids would either overlap or a gap would open up at interface i after a short while. To prevent this a fictional pressure P_i^* is defined at interface i such that the acceleration calculated from the left equals the acceleration calculated from the right.

$$P_i^* \equiv \frac{P_{i+1} f_{i+1}^- + P_i f_i^+}{f_{i+1}^- + f_i^+} \tag{7}$$

where

$$f_i^+ \equiv \frac{1}{\rho_i (r_i - R_i)}, \quad f_{i+1}^- \equiv \frac{1}{\rho_{i+1}(R_{i+1} - r_i)}. \tag{8}$$

In terms of the indicated average $<\rho\delta r>_{i+1/2}$ in Eq. (6′) we can eliminate P_i^* completely from further consideration and use

$$<\rho\delta r>_{i+1/2} \equiv \rho_{i+1}(R_{i+1} - r_i) + \rho_i (r_i - R_i) \tag{9}$$

to define the spatial part of the free average.

The question of how to evaluate the average (9) in time arises and has not been fully settled. The major points to consider are momentum conservation, nonlinear instability of the overall algorithm, and time-centering accuracy. Equation (6′), when multiplied by $<\rho\delta r>_{i+1/2}$ and summed, yields

$$\sum_i V_i^n <\rho\delta r>_{i+1/2} = \sum_i V_i^o <\rho\delta r>_{i+1/2} + \text{boundary terms} \tag{10}$$

where the telescoping pressure terms cancel except at the boundary of the computational region. One would like to use the "old" time values on the right and the "new" time values on the left to give a true momentum "integral" — at least in Cartesian coordinates. Since the quantity $<\rho\delta r>_{i+1/2}$ is conserved in Cartesian Lagrangian coordinates, however, it doesn't really matter at what time we evaluate $<\rho\delta r>_{i+1/2}$, it is just the mass associated with interface i. In non-Cartesian coordinate systems the momentum integral has little meaning and the

quantity $<\rho\delta r>_{i+1/2}$ is not really a constant of the motion... $\rho_i\Lambda_i$ is. ADINC uses an exactly time centered average for the geometric parts of $<\rho\delta r>_{i+1/2}$. The density which appears in the expression is our best approximation (latest iteration) to the new density for reasons of numerical stability.

Return to Eq. (9). ADINC actually uses

$$<\rho\delta r>_{i+1/2} \equiv \left[\rho^P_{i+1}(R^h_{i+1} - r^h_i) + \rho^P_i(r^h_i - R^h_i)\right] \tag{11}$$

where superscript "P" stands for "previous" and indicates the latest iterated approximation to the "new" value of the variable, in this case $\{\rho^n_i\}$. The superscript "h" is used to indicate the exact "half" time average. In Eq. (11)

$$r^h_i \equiv \frac{1}{2}(r^o_i + r^P_i), \quad R^h_i \equiv \frac{1}{2}(R^o_i + R^P_i). \tag{12}$$

We make no representation that these are the best averages or that extensive testing of this aspect of ADINC has been performed. Perhaps the freedom remaining in this region of the calculation can be used to further improve the accuracy and veracity of the algorithm. We do note that no problems arising from this particular choice have been observed to date in numerous test calculations using ADINC.

Returning to the complete algorithm, we wish to find a tridiagonal equation for $\{P^n_i\}$. The momentum equation (6′) can be simplified as follows:

$$V^n_i = a_i - b_i(P^n_{i+1} - P^n_i) \quad \text{for} \quad i = 2, \ldots, N \tag{13}$$

where

$$a_i \equiv V^o_i - \frac{\delta t \epsilon_v}{<\rho\delta r>_{i+1/2}}(P^o_{i+1} - P^o_i),$$
$$b_i \equiv \delta t(1 - \epsilon_v)/<\rho\delta r>_{i+1/2}. \tag{14}$$

The equation of state is introduced by requiring that the cell volume, $\Lambda^{n(eos)}_i$, computed from the equation of state using the new time values of pressure, equal the new cell volume computed from the fluid dynamics, $\Lambda^{n(fd)}_i$. At any iteration P the difference is

$$\delta\Lambda_i^P \equiv \Lambda_i^{P(eos)}(P_i^P,\ S_i,\ \ldots) - \Lambda_i^{P(fd)}\ (\{r_i^P\}) \tag{15}$$

and should be iterated to zero. Changing P_i^P to P_i^n varies both terms in Eq. (15). In the fluid dynamics contribution r_i^P converges to r_i^n as a function of the pressure through Eq. (13) and Eq. (5'). We use effectively a Newton-Raphson approach to obtain a quadratically convergent iteration to the desired solution at time $t + \delta t$

$$\Lambda_i^{n(eos)}(P_i^n,\ S_i,\ \ldots) = \Lambda_i^{n(fd)}(\{r_i^n\}). \tag{16}$$

The difference between $\Lambda_i^{P(fd)}$, which is known at each iteration, and the desired $\Lambda_i^{n(fd)} = \Lambda_i^{n(eos)} = \Lambda_i^n$ can be written in terms of the cell interface areas and the desired new fluid velocities at the cell interfaces.

$$\Lambda_i^n - \Lambda_i^{P(fd)} \approx (1 - \epsilon_r)\ \delta t\left[A_i^h(V_i^n - V_i^P) - A_{i-1}^h(V_{i-1}^n - V_{i-1}^P)\right]. \tag{17a}$$

The same treatment of the equation of state gives

$$\Lambda_i^n - \Lambda_i^{P(eos)} \approx (P_i^n - P_i^P)\left(\frac{\partial\Lambda}{\partial P}\right)^{P(eos)} \tag{17b}$$

Let

$$d_i^+ \equiv -(1 - \epsilon_r)\ \delta t A_i^h \text{ and } d_i^- \equiv -(1 - \epsilon_r)\delta t A_{i-1}^h. \tag{18}$$

Then Eq. (17a) becomes

$$\Lambda_i^n - \Lambda^{P(fd)} \approx -d_i^+(V_i^n - V_i^P) + d_i^-(V_{i-1}^n - V_{i-1}^P). \tag{17a'}$$

Equating Λ_i^n in Eqs. (17a) and (17b) gives

$$\delta\Lambda_i^P + (P_i^n - P_i^P)\left(\frac{\partial\Lambda}{\partial P}\right)_i^{P(eos)} \approx -d_i^+(V_i^n - V_i^P) + d_i^-(V_{i-1}^n - V_{i-1}^P). \tag{19}$$

Define

$$c_i \equiv P_i^P\left(\frac{\partial\Lambda}{\partial P}\right)_i^{P(eos)} + d_i^+ V_i^P - d_i^- V_{i-1}^P - \delta\Lambda_i^P. \tag{20}$$

Then Eq. (19) becomes

$$P_i^n\left(\frac{\partial\Lambda}{\partial P}\right)_i^{P(eos)} + d_i^+ V_i^n - d_i^- V_{i-1}^n \approx c_i. \tag{19'}$$

This is our tridiagonal, implicit, linear equation for the *estimated* new pressures $\{P_i^n\}$ when Eq. (13) is used to eliminate $\{V_i^n\}$ in terms of $\{P_i^n\}$. Expanding this out for completeness gives

$$P_i^n\left(\frac{\partial \Lambda}{\partial P}\right)_i^{P(eos)} + d_i^+\left[a_i - b_i(P_{i+1}^n - P_i^n)\right] - d_i^-\left[a_{i-1} - b_{i-1}(P_i^n - P_{i-1}^n)\right] \approx c_i. \tag{21}$$

Equation (21) is the basic equation solved by ADINC. Iteration is necessary because Eqs. (17a′) and (17b) are only equalities to first order. The iteration is quadratically convergent, however, because only second order terms are neglected at each stage of the iteration. For the interior cells $i = 3, 4, \ldots, N$ Eq. (21) may be written as

$$A_i^* P_{i-1}^n + B_i^* P_i^n + C_i^* P_{i+1}^n = D_i^* \tag{22}$$

where

$$\left.\begin{aligned} A_i^* &\equiv -d_i^- b_{i-1}, \\ B_i^* &\equiv \left(\frac{\partial \Lambda}{\partial P}\right)_i^{P(eos)} - C_i^* - A_i^*, \\ C_i^* &\equiv -d_i^+ b_i, \text{ and} \\ D_i^* &\equiv c_i - d_i^+ a_i - d_i^- a_{i-1}. \end{aligned}\right\} \tag{23}$$

At the right and left boundaries of the system the new velocities are given externally for Eq. (19), (19′). In terms of the tridiagonal coefficients of Eq. (23),

$$\left.\begin{aligned} D_2^* &\equiv D_2^*(\text{above}) + d_2^- V_L^n \\ D_{N+1}^* &\equiv D_{N+1}^*(\text{above}) - d_{N+1}^+ V_R^n, \text{ and} \\ A_2^* &\equiv 0, \quad C_{N+1}^* \equiv 0. \end{aligned}\right\} \tag{24}$$

When integrating the fluid dynamic equations, ADINC assumes that each interface moves in a fully Lagrangian manner according to Eq. (5). The change in density from one timestep to the next in a cell is therefore given simply by the change in cell volume according to the mass conservation equation

$$\rho_i^n \Lambda_i^n \equiv \Delta M_i \equiv \rho_i^o \Lambda_i^o. \tag{25}$$

When individual species number densities must be followed, they are also advanced by Eq.

(25).

The accuracy and stability of ADINC presupposes the monotonicity of the interface positions $\{r_i\}$ with increasing i and, of course, the positivity of the interface areas $\{A_i\}$. Since the algorithm is based on a discretization of the continuum fluid dynamic equations, the possibility exists for numerical error and even instability caused by non-physical crossing of cell interfaces even though the implicit algorithm given above is nominally stable for sound waves at arbitrary timestep. To prevent interface crossings, a Courant condition must still be satisfied for the flow velocities $\{V_i\}$ even though $|V| << C_s \equiv \sqrt{P/\rho^\gamma}$ throughout the fluid (gas). In the reference version of ADINC, reproduced in Appendix A, the maximum timestep which still prevents interfaces crossing adjacent interface positions is calculated from the formula

$$\delta t_{val} = \frac{1}{2} \min_{i=2,N} \left\{ \frac{(r_{i+1} - r_i)}{|V_i|}, \frac{(r_i - r_{i-1})}{|V_i|} \right\} \tag{26}$$

where a very small number is added to $|V_i|$ to prevent dividing by zero.

Equation (26) is conservative and even includes the factor of $\frac{1}{2}$ in case two interfaces are moving toward each other. Generally longer timesteps are quite acceptable. By rights only one of the two terms should be included since an interface can be moving either to the right or the left but not both at the same time. Furthermore, interfaces only cross due to a differential velocity, not an absolute one. The denominators in Eq. (26) should be $|V_{i+1} - V_i|$ and $|V_i - V_{i-1}|$ when a net motion is superimposed on relative expansions and contractions.

Situations exist where the timestep calculated from Eq. (26) can lead to trouble. From Eq. (5') one can see that the cell interface positions are advanced using an average of the new and old velocities. Since the timestep has to be estimated at the beginning of a cycle, it is quite possible for $\{V_i^0\}$ to be small or zero while $\{V_i^n\}$ can be large. If V_i^n becomes large enough, r_i^n can cross adjacent interfaces even though the original timestep estimate should prevent this. The test program reproduced in Appendix B also contains a user-supplied maximum timestep

δt_{max} to provide a limit externally because no fully satisfactory algorithm has yet been developed for ADINC to estimate the limit internally. An estimate of this effect would require dealing with accelerations as well as velocities. This avenue may be impractical because the acceleration calculation must be implicit and would substantially increase the computational cost of the subroutine. In the current algorithm non-convergence of the pressure iteration by a certain amount (discussed below) is signalled through a diagnostic message printed by ADINC but the calculation continues. In principle non-convergence after a certain number of iterations could cause re-initiation of the computational cycle with a smaller timestep. This is not included in the current version for three reasons:

1. Extra data would have to be stored to re-initiate the calculation at additional space and time expense.

2. The ADINC algorithm already subcycles the fluid dynamic calculation when the user specifies a longer integration interval than Eq. (26) permits. Thus the logic is already quite complicated.

3. Crossing of interfaces is usually accompanied by rather drastic numerical errors, not nonconvergence, therefore recovery is problematical at best. The problem usually blows up in the equation of state calculation.

For these reasons I've chosen to put the onus on the user to avoid "sneaky" interface crossings. In practice the timestep given by Eq. (26) is, in fact, conservative not overly ambitious. Few problems have arisen to date.

ADINC is designed to be used as a specific partial differential equation intergrator in much the same spirit as many ordinary differential equation packages are used. It attempts to adjust the timestep and number of iterations at each step internally to maximize speed with good accuracy. Using the timestep estimation algorithm given above, ADINC subcycles the

hydrodynamics as often as necessary to integrate over the full time interval which the user has specified. Since the opportunity exists for an inordinate number of subcycles if something unexpected happens during the calculation, the number of subcycles has arbitrarily been limited to 100. If ADINC performs any subcycles at all, it prints a message to that effect. If the package detects that more than 100 subcycles seem to be required, it terminates the calculation printing a suitable diagnostic message. A user may wish to change these limits.

Within each timestep (or subcycle) the package performs a convergence calculation on the iterated new pressure solution. The convergence condition used for each cell of the calculation is

$$\frac{|P_i^n - P_i^{\dot{P}}|}{P_{\max}} < 10^{-9}\sqrt{\frac{M_{\max}}{M_{\min}}} \tag{27}$$

where $P_{\max}$ is the largest pressure in the system, $M_{\max}$ is the largest cell mass in the system, and $M_{\min}$ is the smallest cell mass in the system. Equation (27) is largely heuristic but has been found to work extremely well. Using the timestep condition given above, convergence is often obtained in two iterations in $\{P_i^n\}$ and almost always in three or four. The maximum number of iterations is limited to six because this should be sufficient to obtain full double precision accuracy using the quadratically convergent algorithm described.

IV. STRUCTURE OF THE ADINC PACKAGE

The ADINC package consists of three subroutines containing three entries each. These FORTRAN subroutines are vectorized for the Texas Instruments ASC system at the Naval Research Laboratory and are reproduced in their entirety in Appendix A. A rather general test program and several simple utility subroutines are reproduced as Appendix B. Here we discuss the three major routines of the package and the interactions between them. The next section considers more practical aspects of how to use ADINC.

The three routines deal with the geometry of the problem, the equations of state of the fluid, and the fluid dynamics of the problem. The geometry of a problem is established and controlled by the subroutine SETGEO and its two entries USEGEO and DTFLOW. The calling sequences and arguments for these entries are as follows:

CALL SETGEO (ALPHA, GEOMCO)
arguments:

ALPHA integer	1 = Cartesian coordinates 2 = Cylindrical coordinates 3 = Spherical coordinates 4 = Power Series coordinates
GEOMCO real*8 array	contains the five coefficients $G_1 - G_5$ of Eq. (4.4) on entry and is only used when ALPHA = 4

CALL USEGEO (RAD, AREA, RADC, LAMC, N)
arguments:

RAD real *8 array	dimension at least $N+1$ — contains $N+1$ interface positions on entry
AREA real *8 array	dimension at least $N+1$ — contains $N+1$ interface areas on exit (Eq.(4))
RADC real *8 array	dimension at least $N+2$ — contains N cell center positions on exit in locations 2, ... $N+1$ (Eq. 5))
LAMC real *8 array	dimension at least $N+2$ — contains N cell volumes on exit in locations 2, ... $N+1$ (Eq. 4))
N integer	contains the number of interior cells on entry

CALL DTFLOW (RAD, VEL, DTVAL, N)
arguments:

RAD real *8 array	dimension at least $N+2$ — contains $N+1$ interface positions on entry
VEL real *8 array	dimension at least $N+2$ — contains $N+1$ interface velocities on entry
DTVAL real *8	contains estimated max timestep to prevent numerical error (on exit)
N integer	contains the number of interior cells in entry

SETGEO is used to establish the geometry of the problem at the beginning of a calculation. Thereafter USEGEO is called to fill the geometric arrays AREA, RADC and LAMC every time a new set of interface positions is obtained during the Lagrangian calculation. The routine remembers the value of ALPHA (and the coefficients GEOMCO where appropriate) until SET-

GEO is called to set up a new problem.

DTFLOW is used to estimate a maximum timestep based on Eq. (26) for use in the fluid dynamic calculation performed by ADINC. The reference version presented in Appendix A calculates a timestep which prevents a new interface position $r_i + V_i \delta t$ from crossing one of the original adjacent interface locations, r_{i+1} or r_{i-1}.

The equation of state of the fluids in each cell of the computation is calculated by the subroutine SETMAT and its two entries SETEOS and USEEOS. The calling sequences and arguments for these entries are as follows:

CALL SETMAT (MATER,MASS,GAMMA,RHOCON,N)
arguments:

MATER real *8 array	dimension at least $N+2$ — contains N cell material identifiers ($i=2, \ldots, N+1$)
MASS real *8 array	dimension at least $N+2$ — contains cell masses on entry
GAMMA real *8 array	dimension at least $N+2$ — contains on entry N cell γ values from Eq. (3)
RHOCON real *8 array	dimension at least $N+2$ — contains on entry N cell ρ_c values from EQ. (3)
N integer	contains the number of interior cells on entry

CALL SETEOS (RHO,PRE,N)
arguments:

RHO real *8 array	dimension at least $N+2$ contains N cell densities on entry
PRE real *8 array	dimension at least $N+2$ — contains N pressures on entry
N integer	contains the number of cells on entry

CALL USEEOS (RHO,PRE,LAMEOS,DLAMDP,N)
arguments:

RHO real *8 array	dimension at least $N+2$ — contains N cell densities $\rho(P, S, \ldots)$ on exit
PRE real *8 array	dimension at least $N+2$ — contains N pressures on entry
LAMEOS real *8 array	dimensional least $N+2$ — containts N cell volumes on exit
DLAMDP real *8 array	dimension at least $N+2$ — containts $d\Lambda/dP$ for each cell on exit
N integer	contains the number of interior cells on entry

SETMAT is used to place the equation of state cell constants into the common block /ADICOM/ which communicates equation of state information among the three routines (nine entries) of the ADINC package. These constants are those conserved quantities and local properties of the fluid cells used to connect the grid configuration at one time to that at another adiabatically. Entry SETEOS is called to determine the entropy for given values of cell density, cell pressure and interface positions. Since thermal conduction, external heating, chemical energy release, etc. all change the entropy but not the other constants in the equation of state, a separate entry from SETMAT is provided to reduce the cost of resetting the equation of state to account for these non-ideal phenomena.

USEEOS is the entry provided to determine the cell density expected, given the cell pressures and all the equation of state constants in ADICOM. Also returned to the user is the cell volume expected and the rate of change of change of cell volume with pressure. These quantities depend on the equation of state only and are used in the ADINC iteration which reconciles the cell volumes computed from the fluid dynamic equations with those needed to satisfy the equation of state. While SETMAT and SETEOS need only be called only once by the user in many types of calculations, USEEOS is called at least two times periteration by ADINC and therefore entails the lion's share of the computational expense.

The common block /ADICOM/ is declared as follows:

```
PARAMETER     NPT = 202
INTERGER      NCELLS
REAL *8       MATERC(NPT), MASSC(NPT), GAMMAC(NPT)
REAL *8       ENTC(NPT), RHOC(NPT)
COMMON        /ADICOM/   MATERC, MASSC, GAMMAC, ENTC, RHOC, NCELLS
```

and appears in the three ADINC routines in exactly the same form. If a user wishes, more complicated formulae may be used for an equation of state. The additional arrays needed would then be added to each realization of /ADICOM/ and the appropriate computations to SETMAT, SETEOS, and USEEOS. The version provided allows a relatively wide selection of problems to be tackled with a relatively simple formulation that is inexpensive to compute.

The quantity MATERC(I) is the material and shell identification of cell i. It is a floating point number of the form L.MM where $0 < L < 10$ is the layer identifier and $0 < MM < 100$ is the local material identifier. The layer number is used by the diagnostics to perform various partial sums. The layer can contain different materials from cell to cell but the layer number must increase monotonically from cell 2 to cell $N+1$. The material identifier MM is not used in the current version but is available for flagging which of several computationally distinct equations of state are to be used in the future. MASSC(I) is the mass (nominally in grams) of cell i. GAMMAC(I), RHOC(I), and ENTC(I) are the equation of state conserved constants for cell i which appear in Eq. (3).

Double precision is used throughout the floating point computations so that problems with

large disparity in cell mass or with nearly incompressible fluids can be treated accurately. The basic convergence criterion of 10^{-9} for the quadratically convergent iteration in ADINC is far more accurate than single precision on the ASC permits. We are using a 64 word length here with an 8 bit (hexidecimal) exponent. The versions of the equation of state and geometry routines are also fully vectorized for efficient computation on the ASC.

The basic fluid dynamic calculation is performed by ADINC and its two entries ADINCO and SETEPS.

CALL ADINC (RAD,VEL,RHO,PRE,N,DTIN,CYCLE,RRNEW,RLNEW,VRNEW,VLNEW)
arguments:

RAD real *8 array	dimension at least $N+1$ — contains $N+1$ interface positions
VEL real *8 array	dimension at least $N+1$ — contains $N+1$ interface velocities
RHO real *8 array	dimension at least $N+2$ — contanis N cell densities
PRE real *8 array	dimension at least $N+2$ — contains N cell pressures

These four arrays of physical variables contain the old timestep values on entry and will be filled with the new timestep values DTIN later on exit. Users should store old values in the external program if desired. The test program shows how to do this.

N integer	contains the number of interior cells on entry
DTIN real *8	the integration timestep on entry
CYCLE integer	the timestep number for identification
RRNEW real *8	on entry the *new* right boundary position
RLNEW real *8	on entry the *new* left boundary position
VRNEW real *8	on entry the *new* right boundary velocity
VLNEW real *8	on entry the *new* left boundary velocity

The boundary interface values are specified at the end of the desired timestep since they are assumed to be driven externally. Usually the positions are fixed and the velocties zero. RAD(N+1), RAD(1), VEL(N+1), (VEL(1) should contain the corresponding old time values.

CALL ADINCO (MODE, CYCLE)
arguments:

MODE integer	= 0 if reinitializing NCALL = 1 if NCALL cumulative-as described in the next section
CYCLE integer	the timestep number for identification

CALL SETEPS (ERO, EVO, MDAMP, EROUT, EVOUT)
arguments:

ERO real *8	basic position explicitness parameter ϵ_r on entry
EVO real *8	basic velocity explicitness parameter ϵ_v on entry
MDAMP integer	number of cycles +1 over which initial filtering by ADINC is desired
EROUT real *8	on exit the most recent value of ϵ_r used by ADINC
EVOUT real *8	on exit the most recent value of ϵ_v used by ADINC

The next section discusses the use of SETEPS to vary the explicitness parameters. The arguments EROUT and EVOUT allow the user to query ADINC about the current values of ϵ_r, ϵ_v being used as well as to change them. The need to monitor the initial filtering feature (discussed in the next section) and the need to print out the time averaged velocities and

pressures actually used to advance the positions (Eq. (5')) and the velocities (Eq. (6')) makes the inclusion of EROUT and EVOUT as arguments to SETEPS a necessity.

Entry ADINCO is provided so the user can monitor the performance of ADINC. Each time ADINCO is called, the number of calls to ADINC, the number of timesteps performed by ADINC, and the number of interations used in these timesteps is printed out. Each call to ADINCO with MODE = 0 reinitializes these counters so we only get the accumulated calls, timsteps, and iterations since the previous call to ADINCO. MODE = 1 controls a special initial filtering facility described in the next section and MODE > 1 is currently not permitted.

The major routine ADINC advances the physical variables $\{r_i\}$, $\{V_i\}$, $\{\rho_i\}$, and $\{P_i\}$ from one timestep to the next. ADINC uses the geometry and equation of state routines and controls all the logic of the iteration and timestep subcycling. The whole package has been written, as nearly as possible, to conform with styles and usage of coupled ordinary differential equation packages. Thus the user can ask the package to integrate over an interval requiring many timesteps. The user can also change the convergence criteria and the order of the algorithm via the ϵ_r and ϵ_v coefficients. Unlike ordinary differential equations, however, partial differential equations require boundary as well as initial conditions. Furthermore, the generally large number of cells and concommitant large number of coupled equations force corresponding restraints as the algorithm. Because the number of simultaneous equations is large, the algorithm must be simple and optimized so the computation time is acceptable. ADINC is second-order accurate at best but is fully vectorized for parallel computation on machines such as the NRL Texas Instruments ASC.

The algorithm described in Section III is a single-step algorithm so numerous copies of the physical variables at different time levels do not need to be maintained. Multiple level predictor-corrector schemes are the norm for ODE packages but require an inordinate amount of computer storage when many equations are coupled as in fluid dynamic problems. The next section considers the use of ADINC for the rather general case provided by the test program in

Appendix B and supported by the utilities there. These utilities perform auxiliary functions useful in the ADINC computation but not crucial to it such as evaluating internal and kinetic energies and initializing a rather general multilayer test problem. These routines and their used are described via comments in the listings in Appendix B. They would not necessarily be used when ADINC is being applied as a package within the context of a more complex computation.

V. USING ADINC

Appendix B contains the listing of a rather general and useful test program for the ADINC package as well as the various utility programs not called by the user directly. Use of most of the ADINC facilities is illustrated there and a thorough understanding of this program and the examples provided in Appendices C, D, and E amounts to a thorough understanding of how to use the ADINC package. Here I present a general discussion designed to give the potential user an overall view of the calculation and such specific information as does not appear elsewhere in this write-up. The three test problems and variations discussed in the next section will illustrate better than any general discussion how physical problems are solved accurately and reliably using ADINC.

ADINC is applied to a user defined fluid problem via a series of structured calls to the 9 entries in the three major routines dealing with geometry, equation of state, and fluid dynamics. Figures 3 and 4 outline the correct sequence for this structured series of calls. Figure 3 contains the computations and routine references required to initialize the package and Figure 4 contains those calculations and calls to be performed during the timestep loop.

The first step in the initialization (Fig. (3)) is to establish the geometry within which the calculations is to proceed. The integer α is set and the values $\{G_i\}$ for $i = 1,2,3,4,5$ are defined if required. Then entry SETGEO is called to transmit these values to ADINC. Then the initial cell interface positions are set by the user so that a call to USEGEO can calculate the interface areas, cell center positions, and cell volumes for the initial grid geometry.

The third step is to set the desired explicitness parameters ϵ_r and ϵ_v into the ADINC package. This is done via the entry SETEPS where the number of timesteps in the initial damping transicent is also communicated to ADINC.

Next the physical problem on the grid must be initialized and communicated to ADINC via the variables in common block /ADICOM/. The physical system has already been divided

Figure 3. To Initialize the ADINC Package

- Determine geometry (α = 1, 2, 3, or 4 and $\{G_i\}$ if needed)
  CALL SETGEO (ALPHA, GEOMCO)
- Determine the initial interface positions $\{r_i\}$ and velocities $\{V_i\}$
  CALL USEGEO (RAD, AREA, RADC, LAMC, N)
  to initialize the interface areas, cell centers, and volumes
- Set the desired explicitness parameters and damping period
  CALL SETEPS (ERO, EVO, MDAMP, EROUT, EVOUT)
  to pass these values on to ADINC
- Determine the desired fluid properties and constants which are conserved with the cell motion
  CALL SETMAT (MATER, MASS, GAMMA, RHOCON, N)
  to set these cell constants into common block /ADICOM/
- Determine the initial cell densities and pressures
  CALL SETEOS (RHO, PRE, N)
  to set the current value of the cell entropies ENTC into /ADICOM/. This has to be repeated in the timestep loop whenever irreversible and dissipative phenomena change the entropy.

Figure 3 — Schematic for initializing the ADINC package. The rather general case presented mirrors the test program of Appendix B. The test program presents, however, a number of additional facilities for use in a scientific research program which are not part of ADINC proper. These do not appear in the schematic.

Figure 4. Application of ADINC During a Timestep

- Establish and limit a monotonically increasing cycle number—
  DO 9999 ISTEP = 1, MAXSTP (in the test program)

- Set a timestep DELTAT which depends on geometry, flow and other considerations. This involves:
  CALL DTFLOW (RAD, DABSV, DTVAL, N)
  where DABSV is an array containing the maximum absolute value of the velocity in the previous two timesteps (DABSV = VEL) works fine in most circumstances. Other timestep limiting calculations should also be performed at this time.

- Perform diagnostics on the geometry and physical variables. This usually involves another
  CALL USEGEO (RAD, AREA, RADC, LAMC, N)
  to update AREA, RADC, and LAMC consistent with current cell interface locations in RAD
  any other diagnostics; including ERGPRT, are performed

- Advance the hydrodynamic variables by first:
  setting the new boundary positions RLNEW, RRNEW and velocities VLNEW, VRNEW before
  CALL ADINC (RAD, VEL, RHO, PRE, N, DELTAT, ISTEP, RRNEW, RLNEW, VRNEW, VLNEW)

- Reset the ϵ_r, ϵ_v values by changing EPSRO, EPSVO in
  CALL SETEPS (EPSRO, EPSVO, MDAMP, EPSR, EPSV)
  9999 CONTINUE (go back for another timestep)

Figure 4 — Schematic for using the ADINC package to integrate the Lagrangian equations of motion. The upper portion of the figure shows the use of ADINC in diagnostics and the lower portion, its use in the integration proper. Additional physics can be added via timestep splitting. This is indicated in the test program.

into a number of computational cells. For each of these Lagrangian cells a number of quantities must be established which are constant throughout the ADINC integration. These can be initialized directly into the /ADICOM/ variables MATERC, MASSC, GAMMAC, and RHOC by the user or auxiliary variables MATER, MASS, GAMMA, RHOCON can be setup and the entry SETMAT called to place these quantities into the common block in the desired locations. The test program fills /ADICOM/ directly but demonstrates the call to SETMAT anyway.

Remember that the $N+1 \equiv$ NCELLS+1 interfaces and associated interface quantities reside in the first through the $N+1$-st locations of interface arrays but the N cells and associated cell quantities must reside in locations 2 through $N+1$. This offset leaves "cell" 1 and "cell" $N+1$ available for fancy boundary conditions or other ghost cell applications. In the test problem, printouts of Appendices C, D and E these undefined quantities appear as the number $2. \times 10^{68}$ or IIIIII or ****** depending on the print out format. Leaving these undefined quantities in the arrays has no adverse effects in the calculations, as will be seen, and does have a potential advantage. Any off-by-one errors introduced in new code by the user will show up as arithmetic exceptions involving the use of these undefined cell quantities.

Once the initial density and pressure in each cell have been set, the cell entropy ENTC can be determined and placed in /ADICOM/. The entry SETEOS performs this calculation using the equation of state function. A separate entry is provided here for efficiency because I anticipate resetting the entropy whenever non-ideal, dissipative, or energy source terms are present. In more complicated systems such as detailed chemically reactive flows even the values of $\{\gamma_i\}$ (GAMMAC) change. The utility DUBLOG is provided and used in SETEOS and USEEOS because the current ASC sysem has an error in the double precision logarithm routine which prevents vectorization. Efficiency in the SETEOS and USEEOS calculations, particularly the latter, is extremely important because these transcendental calculations seem to dominate the ADINC execution time.

The repetitive computations within an ADINC simulation cycle are listed in Fig. 4. The

first part of a cycle is to find the correct timestep, δt (DELTAT in the test program). Entry DTFLOW is provided in the ADINC package to calculate an estimated timestep which will prevent interface crossing but several other timestep limitations, which are normally problem dependent, have to be included. Even though the sound speed is nominally not part of the timestep calculation, it certainly affects the accuracy and the tendency toward non-linear instability. The test program illustrates a number of the considerations involved in timestep selection.

Once the timestep has been chosen I usually recommend that all I/O, dumps, and diagnostics be performed. Since actual integration of the first timestep has not ocurred, performing the diagnostics here within the timestep loop allows the initial conditions to be printed when ISTEP = 1. Thus diagnostic tests and subsidiary calculations have to appear only one place in the code. As part to these diagnostics the geometry variables should be updated as well via USEGEO.

Before calling ADINC to integrate the fluid dynamic equations in the loop, the boundary conditions for the integration step must be established. The values of RRNEW, RLNEW, VRNEW, and VLNEW convey this information to ADINC. On entry $\{r_j\}$, $\{V_j\}$, $\{\rho_j\}$, and $\{P_j\}$ contain the physical quantities at time t, the beginning of the integration step. ADINC is being asked to integrate an internal δt up to time $t + \delta t$. At this time the interior values of $\{r_j\}$ and $\{V_j\}$ will be determined but the boundary velocities V_1 and V_{N+1} and hence the boundary positions depend on external factors. Thus

$$\text{RRNEW} \equiv r_{n+1}\,(t + \delta t),$$

$$\text{RLNEW} \equiv r_1\,(t + \delta t),$$

$$\text{VRNEW} \equiv V_{n+1}\,(t + \delta t),$$

$$\text{VLNEW} \equiv V_1\,(t + \delta t).$$

Nominally VRNEW and VLNEW can be anything but for internal consistency RRNEW should satisfy

$$r_{N+1}(t+\delta t) = r_{N+1}(t) + \epsilon_r \delta t V_{N+1}(t) + (1-\epsilon_1)\delta t\ V_{N+1}(t+\delta t)$$

with a similar equation for $r_1(t+\delta t)$. The test program uses a simplified version of this to avoid the complications of calling SETEPS again just to set the boundary condition. Instead the previous values ϵ_r and ϵ_v are used as these will apply unchanged throughout the calculation except possibly in the first few cycles.

If the values $\{P_i\}$ and $\{V_i\}$ are stored in auxiliary arrays $\{V_i^0\}$ and $\{P_i^0\}$ before ADINC is called, the *average* velocities and pressures used to advance the interface positions and velocities can be calculated as shown in the test program. Even though this information can be reconstructed without special calculation if two sucessive timesteps are printed out, these intermediate values are the basis of the Lagrangian dynamics so the prospective user of ADINC should be familiar with the contents and purpose of DO LOOP 110.

The user of ADINC also has control over the values of the explicitness parameters ϵ_r and ϵ_v for the interface position and velocity integrations. When ϵ_r or $\epsilon_v = 0$, the corresponding equations is fully forward differenced and therefore implicit. When ϵ_r and ϵ_v are both equal to $\frac{1}{2}$, the calculation is fully centered and hence will be second-order accurate in time. The use of $\epsilon_r > \frac{1}{2}$ or $\epsilon_v > \frac{1}{2}$ can lead to numerical instability and is therefore discouraged. The effect of using different values for ϵ_r, ϵ_v is discussed in the next section as part of the sound wave test problem. At any point during the calculation the values of ϵ_r, ϵ_v can be changed by calling the entry SETEPS with the desired values as the first two arguments. The default values are $\epsilon_r = 0.45$, $\epsilon_v = 0.45$ so the calculation will be slightly damped. This setting is good for moderately long timesteps relative to sonic transit times but will eventually damp finite speed sound waves appreciably so the flexibility to change ϵ_r, ϵ_v closer to $\frac{1}{2}$ is important.

A special facility has been built into ADINC to damp out initial transients when long timesteps are being used. The facility is controlled by the third argument of SETEPS, the integer MDAMP. When MDAMP = 1, the facility is disabled making the values of ϵ_r, ϵ_v

constant until the next time they are changed under user control by calling SETEPS with new values.

Before describing exactly what this facility does, it is important to understand why such a facility can be necessary in some problems. Consider a relatively slow flow in which we wish to keep δt large for computational efficiency but where ϵ_r, $\epsilon_v \sim \frac{1}{2}$ is desired for numerical accuracy, i.e. we want to keep the numerical damping small. In such a problem any initial condition of pressures, positions, and velocities can be resolved in high frequency sound waves and slow flow components such as might be driven by thermal conduction, chemical energy release, etc. With $\epsilon \sim 1/2$, the high frequency components will oscillate rapidly and can mask the desired slowly varying solution even though these oscillations are stable. The problem arises because the various initial conditions are slightly incompatible with each other and this incompatibility does not decay away quickly when ϵ_r, ϵ_v are near 1/2. Rather than expending a great deal of effort to filter the initial conditions, it is often perfectly adequate to damp the first few cycles of the ADINC calculation strongly by using ϵ_r, $\epsilon_v < \frac{1}{2}$.

The algorithm implemented linearly increases ϵ_r, ϵ_v from ERO/MDAMP, EVO/MDAMP to ERO, EVO in MDAMP-1 successive calls to ADINC. The default values are MDAMP = 10, ERO = 0.45, EVO = 0.45 if the SETEPS entry is not used. The implementation is quite obvious in Appendix A. Clearly MDAMP = 1 circumvents the changing values of ϵ_r, ϵ_v entirely. Since it may be desirable to perform this filtering operation more than once during a calculation, the facility is provided to reset the counter for the MDAMP-1 filtering steps. Every time ADINCO is called with MODE = 0, the integer NCALL gets reset to zero after the three integers are printed out. When MODE $\geq$ 1, NCALL does not get reset and hence the filtering operation is not performed anew.

The ADINCO entry was provided so the user can diagnose the performance of ADINC at any point in a calculation. When called, the total number of calls to ADINC, the total number

of subcycle steps performed, and the total number of iterations performed since the last called to ADINCO are printed out. Each time ADINCO is called with MODE = 0, the counters are all reset. Using ADINCO to control re-initialization of the filtering facility MDAMP ensures that diagnostic prints are obtained every time the solution is re-filtered.

VI. DISCUSSION OF TEST PROBLEMS

Appendices C, D, and E provide selected printouts from three test calculations using ADINC. These test are chosen to illustrate the use of ADINC in several different and interesting cases, to demonstrate the flexibility and accuracy of the package, to demonstrate some of the control features the user has at his command, and to allow positive code verification via known answers for users implementing the code for themselves. In addition to providing evidence that ADINC and its associated subroutines do something reasonable and accurate in several cases, these test problems provide a jumping off point for many user applications and may be directly adaptable with little or no reprogramming.

The three problems are:

#1. An Adiabatic Sound Wave Test,

#2. An Incompressible Slug Between Adiabatic Gases, and

#3. A LINUS Simulation.

Each test has a main calculation, for which results are printed in the appendices, along with the corresponding data for code verification. In this section a number of auxiliary calculations are also reported to establish properties of the ADINC package with respect to convergence, accuracy, and stability.

#1. An Adiabatic Sound Wave Test (see Appendix C)

The first test problem concerns the ability of ADINC to capture the properties of a sound wave in an ideal gas. The gas is uniform with density 1.4 and pressure 1.0 in the absence of the sound wave. The gas constant $\gamma \equiv 1.4$ ensures a sound speed $C_s = 1.0 \equiv \sqrt{\gamma P/\rho}$. The gas is contained between two rigid, impermeable walls at $x=0$ and $x=1.0$ so a sound wave propagates from $x=0$ to $x=1$ and back in a period of time $\tau=2.0$. The standard test #1 has half a

wavelength between the walls, the velocity being initialized sinusoidally according to

$$V(x,o) = \delta V \sin \pi x \tag{28}$$

where $\delta V(DVEL) = 0.01$ for the standard test. The initial grid is uniform with $\delta x = 0.1$ and the timestep is $\delta t = 0.1$. The standard calculation is thus performed with 20 cells per wavelength and 20 timesteps per period.

The data for this standard test #1 are given in the following table:

Table 1. ADINC Input Data for Standard Test #1—Adiabatic Sound Wave

Namelist /CONTRL/ (program control)	
MAXSTP = 26	DTMIN = 0.1
IPRINT = 1	DTMAX = 0.1
ALPHA = 1	EPSRO = 0.5
N = 10	EPSV0 = 0.5
GEOMCO = (1.0,0.0,0.0,0.0,0.0) (not used if α=1)	
LZONE = .FALSE.	LTCND = .FALSE.
LCHEM = .FALSE.	LTPRT = .TRUE.
LDIFF = .FALSE.	
Namelist /SHLINI/ (layer (shell) initializer)	
NSHELL = 1	MODE = 1
RN = 1.0×10^{-20}	DRHO = 0.0
VN = 0.0	DVEL = 0.01
Namelist /SHLDAT/ (first and only layer)	
LCELLS = 10	MATERS = 1.01
RN = 1.0	GAMMAS = 1.4
VN = 0.0	RHOCS = 0.0
RHOS = 1.4	PRES = 1.0
POWS = 1.0	

Because the peak velocity is small compared to the sound speed, $\delta V/C_s = 10^{-2}$, the evolution of nonlinear effects will be slow and the profiles will remain sinusoidal for a long time. The period of the oscillation is determined by noting when r_6, which starts at 0.5, passes through 0.5 the second time. Since the numerical period computed by ADINC will differ from the exact theoretical period due to finite difference truncation error, interpolation is necessary between timesteps to find the numerical period. This interpolation process has an error associated with it so the numerical period is never found exactly.

The standard test #1 with 20 cells per wavelength and ~20 timesteps per cycle has the

crossing of r_6 through 0.5 occur between cycles 20 and 21. At t=2.0, r_6 = 0.49976 and at t=2.1 the code gives r_6 = 0.50074. The period computed from these values is τ_{code} = 2.0245 ± .001, in error by ~ 1%. This error arises from several sources, the most important of which are the finite timestep and grid size of the calculation. The error from interpolating for r_6=0.5 is twenty times smaller.

Table 2 below summarizes the period computed using ADINC for several values of grid size (initial) and timestep. The number of cells per wavelength and timesteps per period, the important non-dimensional quantities, are also shown.

Table 2. Numerically Computed Period for Adiabatic Sound Wave

cells per wavelength (δx) \ timesteps per period (δt)		10 (0.2)	20 (0.1)	40 (0.05)	∞ (0)
10	0.2	—	2.0526	—	—
20	0.1	2.0714	2.0245	2.0122	—
40	0.05	—	2.0184	2.0061	—
∞	0	—	—	—	2.0000

Since the values of ϵ_r and ϵ_v are both 0.5, the time integration is centered as well as the spatial differences. Therefore we expect full second order accuracy. The coefficients in time and space are different of course since the spatial and temporal algorithms are different. The functional form of the computed period is

$$\tau_{code}(\delta x, \delta t) = \tau_{theory}(1+\alpha(\delta x)^2)(1+\beta(\delta t)^2) + \text{ higher order terms} \qquad (29)$$

where $\alpha \sim 1.6$ and $\beta \sim 3.2$ when δx and δt are measured in units of wavelengths and wave periods respectively. That the above data in Table 2 satisfy Eq. (29) can be seen by the fact that the error in the 20-20 calculation is four times the error in the 40-40 calculation.

In these calculations the layer summaries printed by the test program include energy sums. Subroutine ERGPRT and the diagnostics section of the main program show how these sums are calculated. The interval energy density E_{thrm} is given by

$$E_{thrmi} = P_i/(\gamma_i - 1) \tag{30}$$

for each cell of volume Λ_i. The kinetic energy density is a little more difficult to compute because the interface velocities are known, not the cell center velocities. Averaging the velocities to the cell center introduces a damping term which appears as an overall small amplitude oscillation in the total energy as the wave cycles between potential and kinetic energy.

There is a definition of the kinetic energy which is more consistent with ADINC's finite difference algorithms and which does not display the energy changes that the velocity average definition does. This simple diagnostic uses the fact that ADINC defines cell center positions $\{R_i\}$ and matches accelerations across cell interfaces. Let Λ_i^+ and Λ_i^- be the cell partial volumes to the right and the left of the cell center position respectively.

$$\Lambda_i = \Lambda_i^+ + \Lambda_i^- \tag{31}$$

In the test program $\{\Lambda_i^+\}$ and $\{\Lambda_i^-\}$ are calculated as a simple average but more accurate values can be determined by USEGEO for non-Cartesian geometries. The kinetic energy density in each cell is given by the formula

$$E_{kinci}\ \Lambda_i = \frac{1}{2}\rho_i \left[V_i^2 \Lambda_i^+ + V_{i-1}^2\ \Lambda_i^- \right]. \tag{32}$$

The code diagnostics print out the total energy to nine significant digits and to this accuracy energy is conserved identically. Since the algorithm is nominally reversible, good energy conservation is expected for this sound wave test problem. Essentially perfect energy conservation here means consistent thermal and kinetic energy definitions have been found.

A separate calculation with 20 cells was performed in which the individual zones varied in thickness by a factor of 100, alternating between $\delta x = \frac{10}{101}$ and $\delta x = \frac{.1}{101}$ all the way from x=0 to x=1. The timestep was taken to be $\delta t = 0.05$ and the period was determined to be 2.0121, in error by $\sim$ 0.5%. The conservation of energy for this calculation was again good to 1 part in 10^9 even though ADINC had to subcycle twice at each timestep because some of the

cells were so small. *The wide disparity in cell sizes did not adversely affect the accuracy of the calculation.* Of course the large cells, not the small ones, determine the overall accuracy of the calculation but more realistic problems with widely, varying characteristic scale lengths and/or imbedded discontinuities will be able to take good advantage of this additional flexibility in the ADINC algorithm.

A series of calculations was next performed (with uniform zoning again) where the values of ϵ_r and ϵ_v were varied to determine the amount of sound wave damping implied by forward differencing. It is important to understand that the stability properties usually invoked as benefits of implicit differencing come at stiff price.[10–13] A user of ADINC should perform calculations with ϵ_r, ϵ_v as close to 0.5 as possible so accuracy can be maintained as well as stability. To measure wave damping the energy diagnostic was used to filter out the oscillations. Twenty cells per wavelength and 20 timesteps per cycle were again chosen as the standard conditions. Figure 5 and Table 3 summarize a number of computations performed with different values of ϵ_r and ϵ_v, the ADINC explicitness parameters. The wave amplitude relative to the initial wave amplitude, $\mathcal{A}/\mathcal{A}_0$, is plotted versus the time measured in wave periods (theoretical). $\mathcal{A}(t)$ is determined by subtracting from the total energy, the thermal energy that the system would have with zero velocity. The linearity of $\mathcal{A}/\mathcal{A}_0$ versus t/τ on the semi-logarithmic scale demonstrates that the numerical damping is exponential as expected. Even with the very modest damping introduced by $\epsilon_r = \epsilon_v = 0.45$, the sound wave has decayed by more than a factor of 2.5 in only 10 oscillation periods. This means that the use of fully forward differenced schemes for numerical stability makes the meaningful simulation of sound waves essentially impossible.

Table 3 below summarizes these damping calculations in terms of the per period damping coefficient. The physical sound wave being studied should undergo no damping at all so the loss of energy marks a numerical error which is used here to measure the accuracy of the ADINC algorithm. Variation of damping with ϵ_r, ϵ_v, timestep δt, and grid size δz is shown.

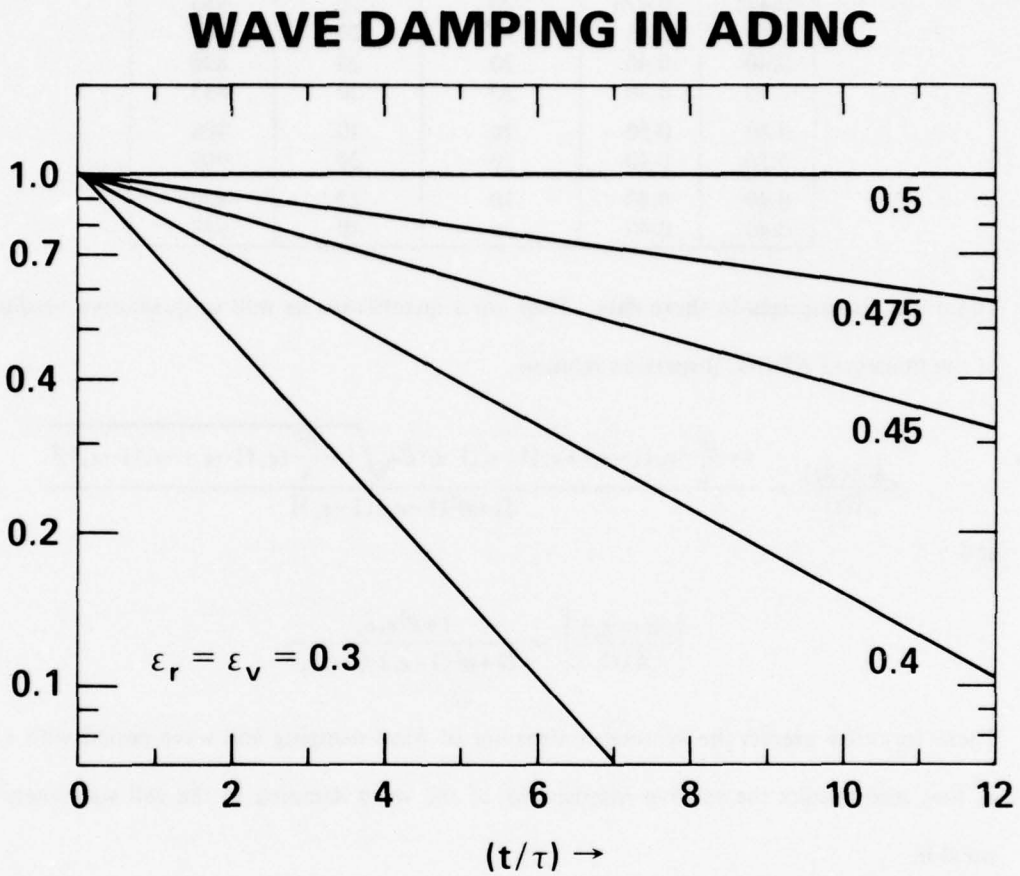


Figure 5 — Wave amplitude as a function of time illustrates damping introduced by forward differencing. Amplitudes are measured in units of the initial amplitude. The values of the explicitness parameters are shown. With $\epsilon_r = \epsilon_v = 0.45$, for example, the wave has damped by a factor of >2.5 in ten periods of the wave.

Table 3. Variation of wave damping coefficient (per period) with numerical control parameters. The physical wave should be undamped.

ϵ_r	ϵ_v	cells per wavelength	timesteps per period	damping coefficient
0.50	0.50	20	20	>.998
0.475	0.475	20	20	.953
0.45	0.45	20	20	.909
0.40	0.40	20	20	.826
0.30	0.30	20	20	.683
0.40	0.50	20	20	.908
0.50	0.40	20	20	.909
0.40	0.40	10	20	.830
0.40	0.40	20	40	.907

There are no surprizes in these data. They are a quantitative as well as qualitative verification of the linearized ADINC dispersion relation

$$\frac{\mathcal{A}(t+\delta t)}{\mathcal{A}(t)} = \frac{1-\frac{\beta^2}{2}[\epsilon_v(1-\epsilon_r)+\epsilon_r(1-\epsilon_v)] \pm i\beta\sqrt{1-\frac{\beta^2}{4}[\epsilon_v(1-\epsilon_r)-\epsilon_r(1-\epsilon_v)]^2}}{[1+\beta^2(1-\epsilon_r)(1-\epsilon_v)]} \tag{33}$$

and

$$\left|\frac{\mathcal{A}(t+\delta t)}{\mathcal{A}(t)}\right|^2 = \frac{1+\beta^2\epsilon_r\epsilon_v}{[1+\beta^2(1-\epsilon_r)\ (1-\epsilon_v)]} \tag{34}$$

These formulae predict the symmetric behavior of wave damping and wave period with ϵ_r and ϵ_v they also predict the relative insensitivity of the wave damping to the cell size when δx is small in

$$\beta \equiv \frac{2C_s\delta t}{\delta x}\sin\frac{k\delta x}{2} \quad . \tag{35}$$

The next set of tests performed concerned the nonlinear behavior of sound waves computed by ADINC. Three variations of the standard test #1 were performed in which δV, the initial sinusoidal velocity maximum, was increased to 0.1, 0.3, and 0.5 times the speed of sound in the system. Figure 6 shows four normalized velocity profiles at cycle 40 in the three calculations, two linear wave periods after the calculation is initialized. The linear (sinusoidal) profile

NONLINEARITY IN STANDARD TEST #1

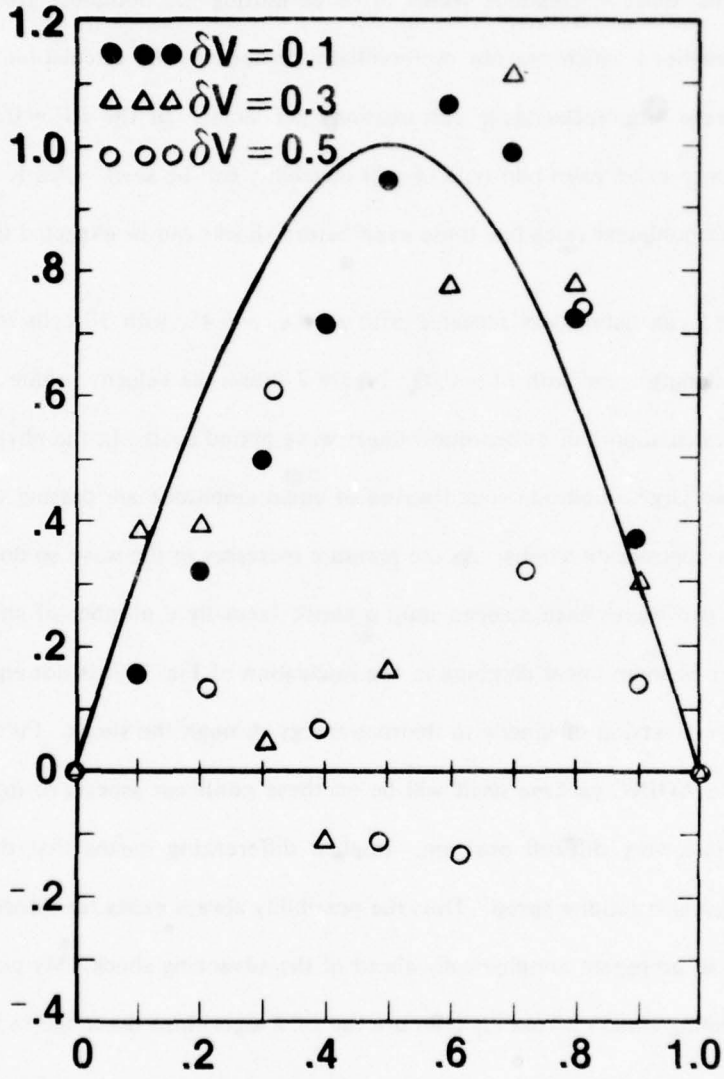


Figure 6 – Nonlinearity in Standard Test #1. Without damping, increasingly nonlinear initial sound waves develop short wavelength oscillations proportionately faster. The profiles are scaled; the sinusoidal linear solution after two periods is also shown for comparison.

is shown as the solid line for comparison.

In the $\delta V = 0.1$ case the calculation required more iterations than in the previous cases and ADINC had difficulty with convergence criteria during some of the timesteps. The choice of $\epsilon_r = \epsilon_v = 0.5$ for these calculations seems to be permitting the nonlinear growth of short wavelength perturbations which are not preferentially damped in the calculation. At proportionately larger wave amplitudes these perturbations get larger. In the $\delta V = 0.5$ undamped case, strong evidence of an even-odd type of grid instability can be seen. Clearly some damping is necessary for nonlinear cases like these even before shocks can be expected to form.

The $\delta V = 0.5$ calculation was repeated with $\epsilon_r = \epsilon_v = 0.45$, with 30 cells in the system (60 cells per wavelength), and with $\delta t = 0.02$. Figure 7 shows the velocity profile at a series of times during the calculation half a theoretical linear wave period apart. In the physical problem simulated here two large amplitude sound waves of equal amplitude are passing through each other travelling in opposite directions. As the pressure increases in the wave so does the sound speed. Thus the two waves each steepen until a shock (actually a number of shocks) forms. Even though there is some linear damping in the calculation of Fig. 7, it is not enough to provide the required conversion of kinetic to thermal energy through the shock. Future emphasis of research on the ADINC package itself will be on these nonlinear aspects of implicit hydrodynamics. This is a very difficult problem. Implicit differencing means that the numerical "characteristic" travels at infinite speed. Thus the possibility always exists for information about the shocked fluid to propagate nonphysically ahead of the advancing shock. My current recommendation for treating shocks accurately is to use the FCT algorithms described in refs. 14-16.

#2. An Incompressible Slug Between Adribatic Gases (see Appendix D)

The second test problem is illustrated in Figure 8. There are three layers bounded on the left and on the right by rigid impermeable walls. The center region is an incompressible slug. The left and right regions are each adiabatic gas layers of exactly the same properties as the sin-

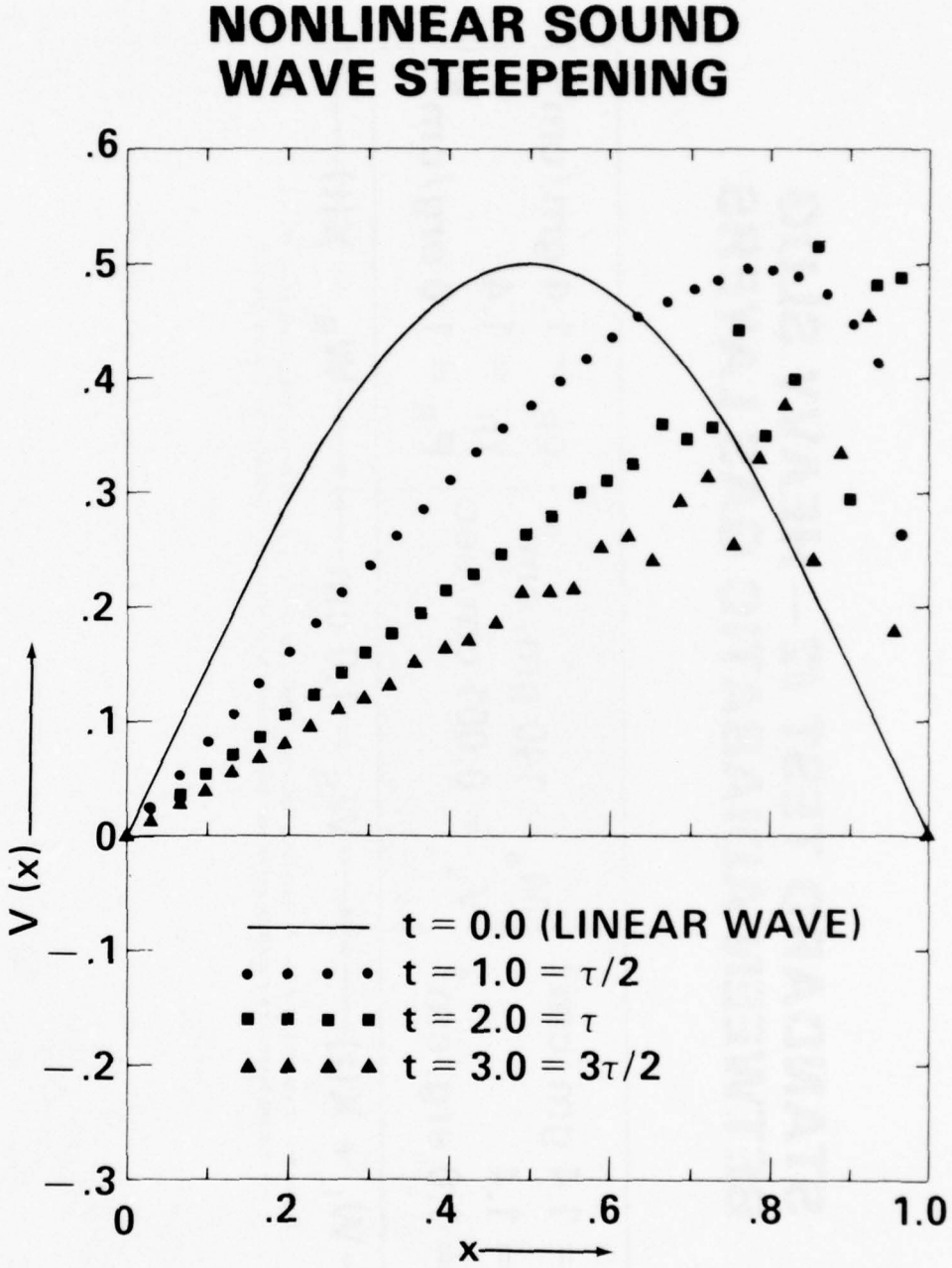


Figure 7 — Velocity profiles of nonlinear sound wave steepening. The four curves are taken half a (theoretical linear) period apart. The $\tau/2$ and $3\tau/2$ data are inverted + for − and flipped left for right on the plot so that the nonlinear evolution is evident. With $\epsilon_\rho = \epsilon_v = 0.45$ as in this calculation, there is not enough dissipation to maintain monotonicity at the shock.

STANDARD TEST #2 — HEAVY SLUG BETWEEN ADIABATIC GAS LAYERS

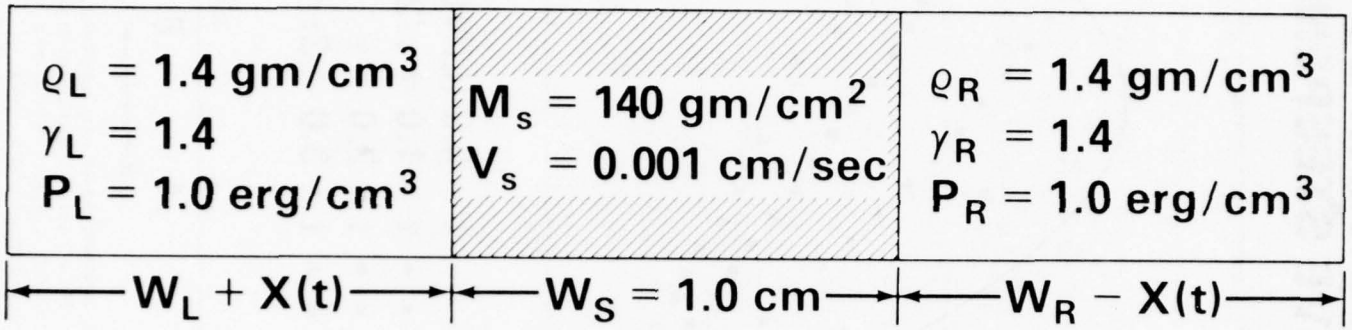


Figure 8 — Standard Test #2 — A heavy Slug Between adiabatic gas layers. A slug of density 140 and thickness $W_s = 1$ is situated between two adiabatic gas layers. Each adiabatic layer is exactly as treated in the first test problem.

gle gas layer considered as standard test #1. The large density discontinuities across the two layer interfaces makes this a test of the acceleration-matching part of the ADINC algorithm. Without this correction the effective mass of the slug would vary by half a cell or so hence finite difference errors would be of order 5%.

Detailed comparisons require an analytic solution. Let the slug have a mass M_s per cm^2 and a density ρ_s. The right and left hand adiabatic gas layers have densities which are determined by the location of the moveable slug. At the initial time t=0 the slug is at the equilibrium position but moving with a nonzero velocity V_s. The initial pressures are equal, $P_R = P_L$, but the densities, ρ_R and ρ_L, the width of the regions, W_R and W_L, and the gas constants, γ_R and γ_L, can all be different. This system is soluble both in the linear and in the asymptotic nonlinear limit and thus permits a detailed evaluation of the accuracy of the numerical techniques.

Let the displacement of the slug from equilibrium be denoted by $X(t)$. Then

$$\begin{aligned} W_L(t) &= W_L + X(t) \qquad P_L(t) = S_L W_L^{-\gamma_L}(t) \\ W_R(t) &= W_R - X(t), \qquad P_R(t) = S_R W_R^{-\gamma_R}(t) \end{aligned} \tag{36}$$

where the fixed entropies S_L and S_R can be determined from the initial conditions. There are two equations to be solved,

$$\begin{aligned} \frac{dX(t)}{dt} &= V(t) \quad \text{and} \\ M_s \frac{dV(t)}{dt} &= P_L(t) - P_R(t). \end{aligned} \tag{37}$$

Linearizing gives $P_L(t) \approx P_L - \gamma_L S_L W_L^{-\gamma_L - 1} X$. With a similar expression for $P_R(t)$. The equilibrium terms cancel and

$$M_s \frac{dV(t)}{dt} = -X(t)\left[\frac{\gamma_L P_L}{W_L} + \frac{\gamma_R P_R}{W_R}\right] \tag{38}$$

Let $X(t) = X_o \sin\omega t$ where $V_s = \omega X_o$. The resulting dispersion relation is

$$\omega^2 = \left[\frac{\gamma_L P_L}{W_L} + \frac{\gamma_R P_R}{W_R}\right] / M_s . \tag{39}$$

The test calculations performed on this problem with ADINC have $W_R = W_L = 1.0$cm and the slug density $\rho_s = 140$ gm/cm^3, the slug length is 1.0 cm, and $M_s = 140$ gm/cm^2. The initial gas layer pressures are 1.0 dyne/cm^2 and $\gamma_L = \gamma_R = 1.4$. With these parameters the frequency $\omega = \sqrt{2.8/140} = .141421$ and the period $\tau = \frac{2\pi}{\omega} = 44.4288$ is expected.

Actually we should not neglect the mass of the gas because ADINC won't. When the density ratio is large as it is here, the velocity will vary roughly linearly across the gas regions in order that the density and pressure stay spatially constant. The effective mass of the slug therefore increases by half of the mass of each of the gas regions. Equation (39) becomes

$$\omega^2 = \frac{[\gamma_L P_L/W_L + \gamma_R P_R/W_R]}{[M_s + \frac{1}{2} M_L + \frac{1}{2} M_R]} \tag{40}$$

which predicts a period $\tau = 44.6504$ *sec.* Here I will not attempt still higher order corrections which arise from the curvature of the gas layer profiles, i.e. the fact that the density cannot be constant if there is a pressure variation across the gas layer. These are of order $1{:}10^{-4}$ and are about as large as the interpolation error in evaluating the data, ± 0.001 sec.

The data for the standard test #2 are given in the following table:

Table 4. ADINC Input Data for Standard Test #2—Incompressible Slug Between Adiabatic Gases

Namelist/CONTRL/ (program control)

MAXSTP = 26	DIMIN = 1.0
IPRINT = 1	DTMAX = 1.0
ALPHA = 1	EPSR0 = 0.5
N = 10	EPSV0 = 0.5

GEOMCO = (1.0, 0.0, 0.0, 0.0, 0.0) (not used if α=1)

LZONE = .FALSE.	LTCND = .FALSE.
LCHEM = .FALSE.	LTPRT = .TRUE.
LDIFF = .FALSE.	

Namelist /SHLINI/ (layer (shell) initializer)

NSHELL = 3	MODE = 1
RN = 1.0×10^{-20}	DRHO = 0.0
VN = 0.0	DVEL = 0.0

Namelist /SHLDAT/ (first layer data)

LCELLS = 5	RN = 1.0	VN = 0.001
MATERS = 1.01	POWS = 1.0	RHOCS = 0.0

GAMMAS = 1.4	PRES = 1.0	RHOS = 1.4
Namelist /SHLDAT/ (second layer data)		
LCELLS = 5	RN = 2.0	VN = 0.001
MATERS = 2.02	POWS = 1.0	RHOCS = 140
GAMMAS = 0.5	PRES = 1.0	
	RHOS = 140.000000000140	
Namelist /SHLDAT/ (third layer data)		
LCELLS = 5	RN = 3.0	VN = 0.0
MATERS = 3.01	POWS = 1.0	RHOCS = 0.0
GAMMAS = 1.4	PRES = 1.0	RHOS = 1.4

In the second layer, absolute incompressibility is not forced so it can be used as a diagnostic of ADINC's accuracy. The density in this slug satisfies

$$\rho_s = 140 + (P/S)^2 \tag{41}$$

where the initial value of $\rho_s = 140[1 + 10^{-12}]$ is used in conjunction with $\rho_c = 140$ in the initializer to determine $S = 8.4516\times10^4$. In this second test, therefore, density fluctuations of order 10^{-16} are expected physically. This is smaller than roundoff error. The calculations described below all have the slug density constant to at least 1 part in 10^{10}, about the convergence criterion for the nonlinear iteration in ADINC.

The ADINC package, of course, accepts a wide continuous range of values for ρ_c, γ, and S in the formulae for the equation of state but for only a few values of gamma is the energy integral readily computable (I believe). When $\rho_c = 0$ in Eq. (3), for example, the energy density E is given by the familiar formula

$$E = P/(\gamma-1). \tag{42}$$

when $\rho_E \neq 0$, E is given by the integral

$$E = \frac{S}{L}\int_{L}^{L_c} (\rho(L') - \rho_c)^\gamma \, dL' \tag{43}$$

where

$$\rho(L') = \rho_c L_c / L' \tag{44}$$

and L_c is the size of the system when $\rho = \rho_c$. The integral (43) is basically just an evaluation of

the $\int PdV$ work done on the fluid.

When $\gamma = 1/2$, as in the test case, the integral can be performed in closed form.

$$E = P\left\{\frac{\rho}{\rho_c}\,\frac{\tan^{-1}(\rho/\rho_c - 1)^{1/2}}{(\rho/\rho_c - 1)^{1/2}} - 1\right\} \tag{45}$$

This formula for the internal energy density goes to zero in the zero pressure $\rho = \rho_c$ limit. As will be seen in the test calculation of Appendix D, the internal energy calculated for the slab is thirteen orders of magnitude smaller than the thermal energy of the gas layers. This indicates near perfect effective incompressibility of some finite difference cells immediately adjacent to cells whose equation of state requires compression. Equation (45) is implemented as an energy diagnostic for all cells having $\gamma = 1/2$ in the test program so that future users may see examples of how the solution quality varies as a result of varying both physical and numerical parameters in the calculation.

Again temporal and spatial resolution are expected to play major roles in determining the accuracy of the computed solution. Table 5 below summarizes the results of a number of test calculations with varying timestep and cell size.

Table 5. Numerically Computed Period for Oscillatory Incompressible Slug

NCELLS \ timesteps per period	$\delta x =$ \ δt	~10	~20	~40	∞
		4.0	2.0	1.0	0
3	1.000	45.7972	44.9430	44.7234	—
15	.200	45.7269	44.8727	44.6534	—
∞	0	—	—	—	~44.6504

As can be seen, the timestep plays a much larger role here in the accuracy than the spatial resolution. The errors in the temporal integration are about the same as for the pure sound wave when δt is measured in units of the appropriate period. Here the slug is very heavy so the period is much longer than in test #1 reported above. At ~20 timesteps per period the error is

again between 0.5% and 1% even though the period is theoretically more than 22 times longer for the slug than for the sound wave. This suggests a usefull rule of thumb. *Expect* $\lesssim$ *1% errors in computating phenomena with a characteristic period of twenty finite difference timesteps. Faster* phenomena will be less accurate, slower phenomena more accurate. Computed periods seem to be slower than theoretically expected.

The acceleration matching algorithm in ADINC is the reason that the computed slug period is insensitive to the spatial resolution. The interfaces are perfectly resolved and any density discontinuities are automatically treated with high accuracy as long as pressure variations are linear between cell centers and adjacent interfaces.

As with standard test #1, the nonlinear limit of this oscillatory slug problem is interesting. When the pressure in the gas layers is low relative to the kinetic energy of the slug, the slug travels from one wall to the other at essentially constant velocity where it then rebounds specularly. Therefore, to lowest order anyway, the period of oscillation will be

$$\tau = \frac{2(W_L + W_R)}{V_s} \quad . \tag{46}$$

Equation (46) gives only the limiting value, of course, valid when the gas layer compresses to vanishing thickness during rebound. Figure 9 plots the slug frequency $1/\tau$ determined numerically as a function of the maximum slug velocity. Clearly the correct asymptote is being approached. As the slug velocity approaches the sound speed of the gas in the adiabatic layers, however, the flow becomes complicated and shock dissipation (which ADINC cannot handle properly) will become important.

As in standard test #1, further investigations of steepening sound waves will be deferred until a future paper. New users of ADINC might find it very instructive to boost the sound speed (or lower the pressure) in the gas layers to allow a faster slug velocity without generating a shock in the buffer layers. In principle the density of these layers can always be dropped far enough with $P = 1$ so that any given slug velocity V_s will be subsonic throughout the

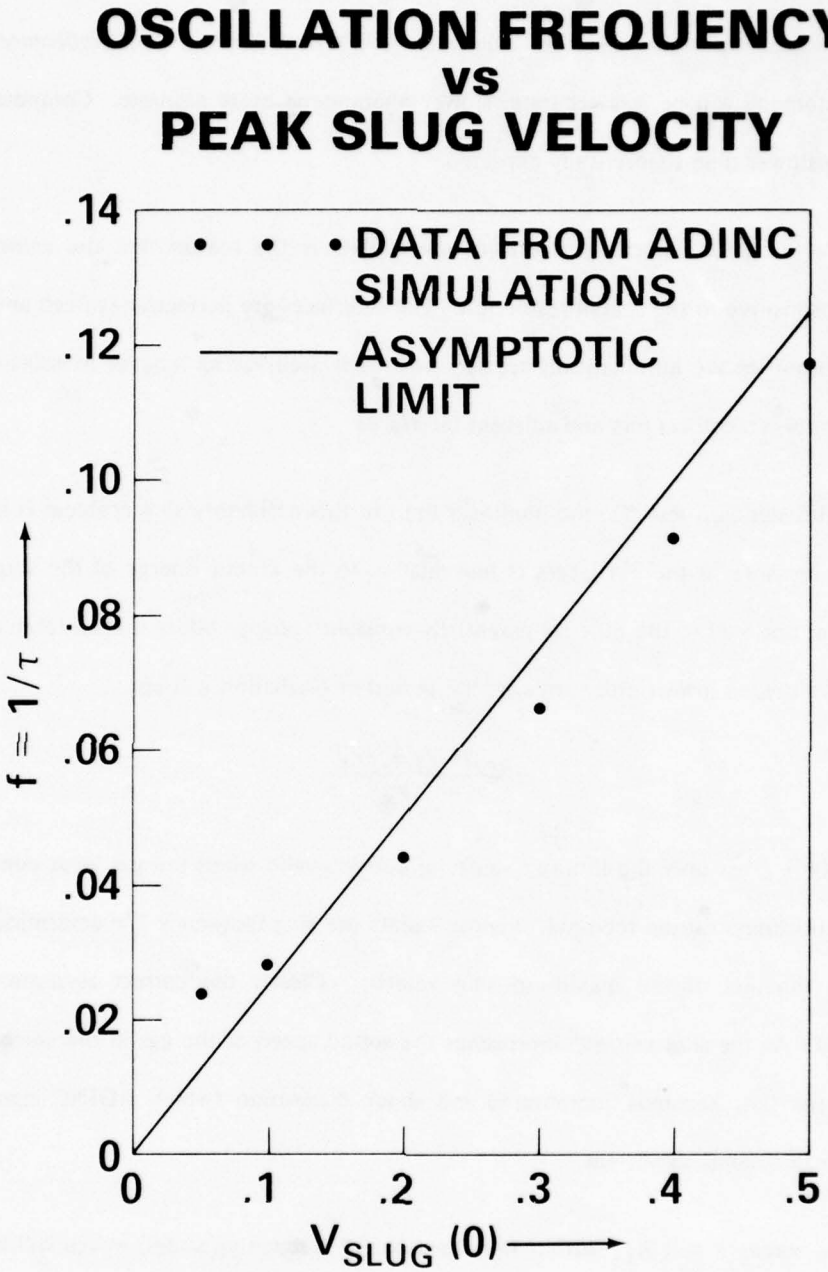


Figure 9 — Oscillation frequency versus peak slug velocity. For V_S near zero the frequency is essentially constant at the theoretical value given by Eq. (40). For large velocities the slug always travels close to but below the peak velocity so the actual frequency lies somewhat below the asymptotic limiting curve.

compression and rarefaction phases of the slug oscillation. When shocks do develop, I recommend the FCT algorithms discussed in refs. 14-16.

#3. A LINUS Simulation (see Appendix E)

The problem which necessitated writing ADINC in its current form, more than any other, is the simulation of the slightly compressible liquid liners used in Linus[6-8]. Original treatment of the plasma/magnetic field/liner system assumed the cylindrical plasma/magnetic field core was being compressed by a constant density, incompressible, ideal liquid flowing radially inward. The compressibility of the liner actually can have a substantial effect on the dynamics, energetics and dwell time of the implosion. Hence the desire to simulate acoustic phenomena accurately for time periods long compared to a sonic transit time became a necessity. Fully forward differenced schemes and even the quasi-static iteration used originally for Linus[10-13] would not perform this calculation well. Therefore ADINC was developed with the capability for central as well as forward differencing under programmer control.

The geometry of the calculation is shown in Figure 10 with the reference values of the coordinates diplayed. Five cylindrical shells are used with a 100 atmosphere pressure in the driver gas plenum. The input data for the standard test #3 are given in the following table:

Table 6. ADINC Input Data for Standard Test #3—A LINUS Simulation

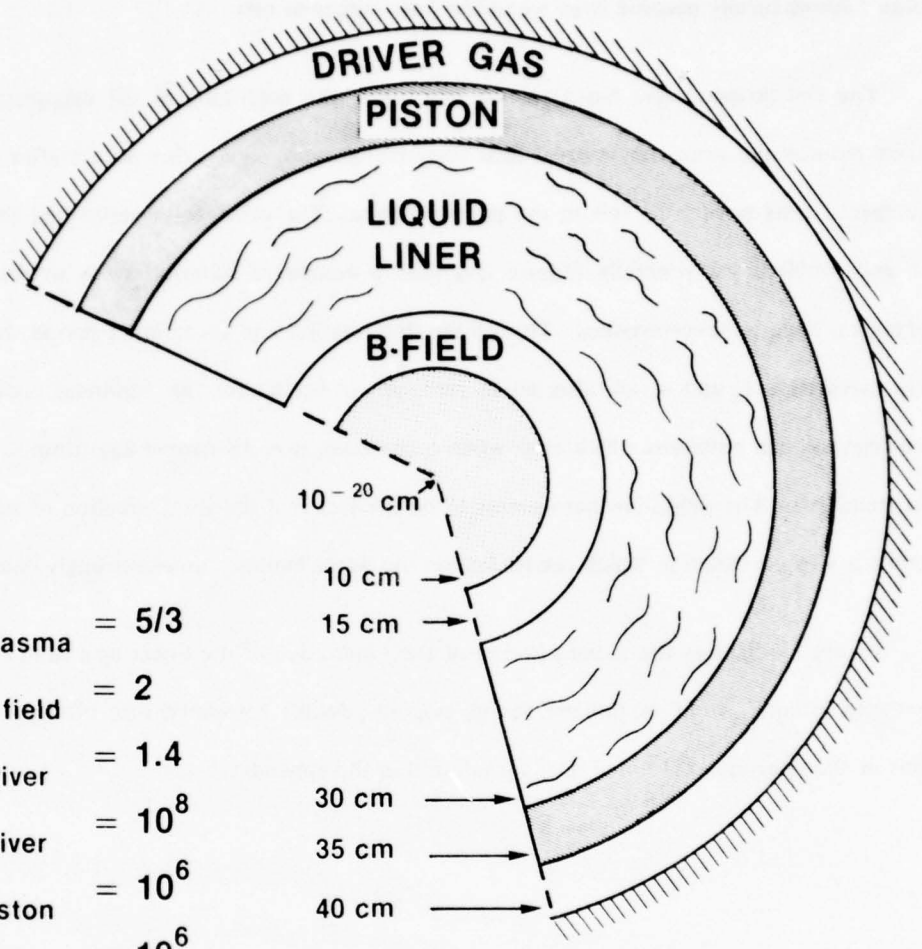
Namelist/CONTRL/ (program control)		
MAXSTP = 1001	DTMIN = 10^{-7}	
IPRINT = 50	DTMAX = 10^{-4}	
ALPHA = 2	EPSR0 = 0.45	
N = 30	EPSV0 = 0.45	
GEOMCO = (1.0, 0.0, 0.0, 0.0, 0.0) (not used since α=2)		
LZONE = .FALSE.	LTCND = .FALSE.	
LCHEM = .FALSE.	LTPRT = .TRUE.	
LDIFF = .FALSE.		
Namelist /SHLINI/ (layer (shell) initializer)		
NSHELL = 5	MODE = 1	
RN = 10^{-20}	DRHO = 0.0	
VN = 0.0	DVEL = 0.0	
Namelist /SHLDAT/ (plasma layer data)		
LCELLS = 3	RN = 10.0	VN = 0.0

MATERS = 1.01	GAMMAS = 5/3	RHOCS = 0.0
POWS = 1.0	PRES = 10^6	RHOS = 1.2×10^{-3}
Namelist /SHLDAT/ (B field layer data)		
LCELLS = 2	RN = 15.0	VN = 0.0
MATERS = 2.02	GAMMAS = 2	RHOCS = 0.0
POWS = 1.0	PRES = 10^6	RHOS = 1.2×10^{-3}
Namelist /SHLDAT/ (liquid (water) liner)		
LCELLS = 15	RN = 30.0	VN = 0.0
MATERS = 3.03	GAMMAS = 0.5	RHOCS = 1.0
POWS= 2.0	PRES = 10^6	
RHOS = 1.0000000001		
Namelist /SHLDAT/ (piston layer)		
LCELLS = 5	RN = 35.0	VN = 0.0
MATERS = 4.04	GAMMAS = 0.5	RHOCS = 7.8
POWS = 1.5	PRES = 10^6	
RHOS = 7.80000000078		
Namelist /SHLDAT/ (driver gas plenun)		
LCELLS = 5	RN = 40.0	VN = 0.0
MATERS = 5.05	GAMMAS = 1.4	RHOCS = 0.0
POWS = 1.0	PRES = 10^8	RHOS = 0.12

Several outputs from the complete calculation are included in Appendix E. A number of ad hoc modifications of the test program were also included for this particular calculation. In the timestep control portion of the program, the initial timestep is taken as the geometric mean of the minimum and maximum values specified. In a problem where geometric convergence is strong, as in standard test #3, the spread between δt_{min} and δt_{max} has to be large. Thus the initial timestep is unspecified when all the velocities are zero.

This type of calculation starts with an implosion. The liner accelerates radially inward until the plasma-magnetic field core becomes highly compressed. When the pressure interior to the liner is high enough, the implosion comes to rest and is then converted to an accelerating explosion. At "turn around" the liner comes to rest. At this time, the timestep computed by DTFLOW is large because the fluid is moving slowly even though the accelerations are maximum. To avoid the problem of taking too large a timestep, users might be well advised to include in the timestep control portion of their codes, an estimate of the change in velocity expected during the step as well as the actual velocity at the beginning of the step. In the test program here this problem has been tackled in two ways. Both the old velocity and the current

LINUS SIMULATION INITIAL CONDITIONS



$\gamma_{plasma} = 5/3$

$\gamma_{B\ field} = 2$

$\gamma_{driver} = 1.4$

$P_{driver} = 10^8$

$P_{piston} = 10^6$

$P_{liner} = 10^6$

$P_{plasma} = 10^6$

$P_{B\ field} = 10^6$

$\rho_{liner} = 1\ gm/cc + (P/S_{liner})^2$

$\rho_{piston} = 7.8\ gm/cc + (P/S_{piston})^2$

INITIAL VELOCITIES ZERO

Figure 10 — A schematic of the LINUS simulation initial conditions. A five layer calculation involving liquids, gases, and plasma. Parameters of the calculation are close to those used in recent LINUS 1 experiments at NRL with the exception of replacing the plasma and magnetic field with a $\delta = 1.4$ gas.

velocity are used to get the smallest estimate of δt available. Then the estimated δt is limited to be no more than 1.1 times the previous timestep. This last operation ensures that the step doesn't automatically become large when the liner comes to rest.

The test program also has a section of code at the beginning of the diagnostics portion which reduces the print out interval near liner turnaround. Since this occurs after cycle 650, the special tests have been left in the main program. The other tests performed for problem #1 and problem #2 generally require less than a couple of hundred steps so this problem dependant code is never invoked. During the deceleration and turnaround period the explicitness parameters ϵ_r and ϵ_v are also set to zero, an *ad hoc* fix for the nonlinear instability and non-convergence problems which arise when a centered, non-dissipative algorithm is subject to fast transients. The limitation here seems to be the fact that the solid equation of state cannot permit $\rho < \rho_c$, a situation which occurs behind the water hammer unless strongly damped.

Figure 11 displays the radial position of the inner edge of the linear as a function of time near turn around. Some asymmetry seems evident-possibly correlated with the weak compressions of the liner material noted near turnaround in the appendix.

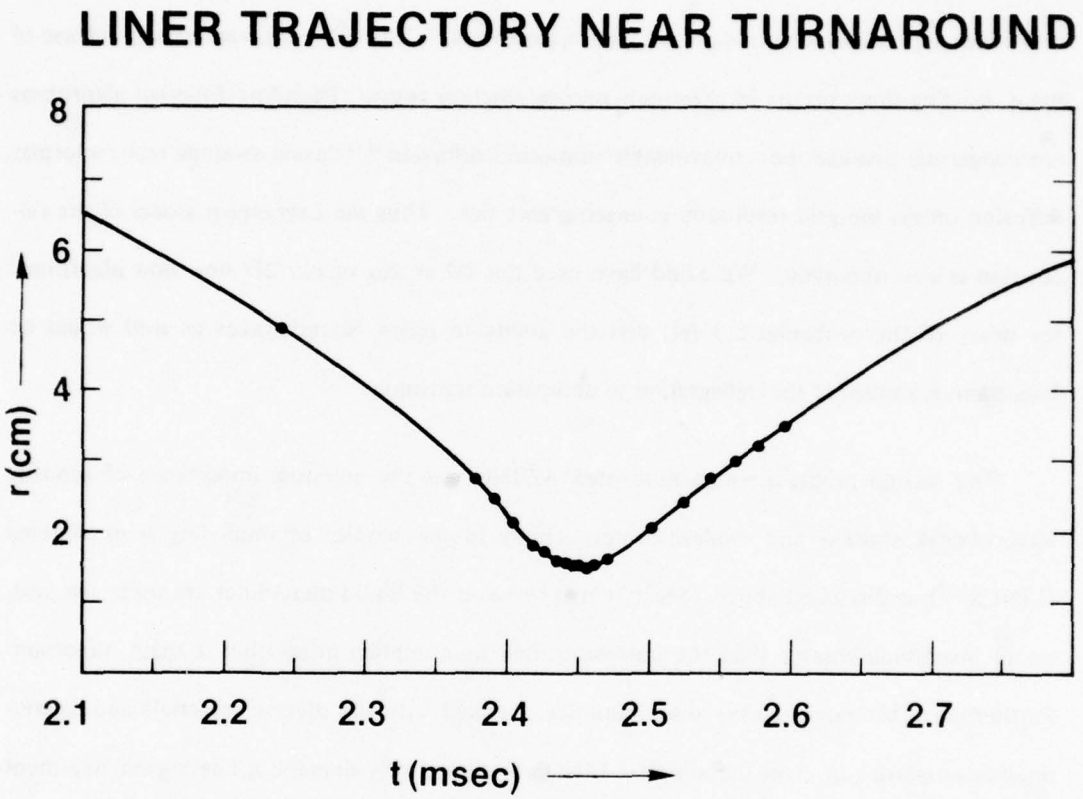


Figure 11 — Trajectory r vs t of the inner edge of the liner at turnaround. A very slight compression of the liner material is expected for these parameters with a corresponding modification of the trajectory near turnaround.

VII. DISCUSSION

ADINC was originally motivated by four related but distinct computational problems. The first of these was the need to extend our detailed reacting shock model[17] to treat flame propagation and similar reacting flow problems where chemistry and fluid dynamics interact on timescales appreciably slower than the sonic transit time.[18] The self consistent energy release of many reacting flows occurs in extremely narrow reaction zones. Therefore Eulerian algorithms are dangerous because their unavoidable numerical diffusion[14-16] usual swamps real molecular diffusion unless the grid resolution is unacceptable fine. Thus the Lagrangian aspect of the calculation is also important. We could have used the 1D analog of our 2D slow flow algorithm[5] for many of the problems but felt that the ability to follow sound waves as well would be important in studies of the deflagration to detonation transition.

The second problem which motivated ADINC was the potential importance of acoustic waves (weak shocks) and modest compressibility in the physics of imploding liner systems (LINUS[6-8]) as discussed above. Sonic transit times in the liquid metal liner are up to two orders of magnitude shorter than the implosion time thus implicit integration is again important. Furthermore, the large density discontinuities, coupled with the diverse materials and discontinuous properties in even the simplest LINUS system clearly demand a Lagrangain treatment of at least the material interfaces.

The third problem which led to ADINC was the desire to develop a fully compressible version of our two-dimensional hydrodynamics code SPLISH[19,20] which would allow discontinuous material interfaces and reasonable approximations to real equations of state. SPLISH is Lagrangian and uses a reconnectable grid of triangles to permit long time integration of strongly sheared flows. Because of the complexity of the SPLISH variable geometry, it was clearly going to be profitable to perform tests of the proposed compressible algorithms in one dimension first. ADINC fills this role as well.

The fourth problem which motivated ADINC is the detailed simulation of a laser-driven ablation. The detailed analysis of the structure of this ablation[21] predicts a thickness for the ablation layer of less than 0.1 μ but the sound speed in this region can exceed 10^7cm/sec. Thus picosecond timesteps would be required for explicit courant stability — a strong inducement to look for accurate implicit algorithms since 10 nsec and longer experiments have to be simulated. Here, as in the LINUS problem, a single calculation must span the range of densities from solid or greater to a tenuous gas. Furthermore, the vast span of zone sizes required for different regions of the flow clearly requires special treatment to retain accuracy.

The three test problems presented above were designed to give the prospective user of ADINC a useful background of experience with the program in different regimes and with different problems. Various types of errors were tested and discussed but clearly a lot of work is required on shocks and other strong nonlinear sonic phenomena. In particular, until an adaptive rezoning algorithm is included, even the flexible initial zoning allowed by varying the parameter POWS in Namelist /SHLDAT/ is not adequate to deal accurately with a number of problems. Auxiliary reports in this series will present and test additions to the ADINC package for this rezoning, for more realistic equations of state, and for propagating discontinuities and shocks.

ADINC is an evolving package and its users are part of the evolution process. Your comments and suggestions for improving or simplifying the calculation will certainly be taken into account in future editions of the package. Comments on omissions and inaccuracies in this documentation will also be gratefully received and incorporated.

ACKNOWLEDGEMENT

This work was supported by the Office of Naval Research under projects RR014-03 and RR011-09-41 and by the Naval Material Command, project ZF43-451-001. The author would like to acknowledge useful conversations with K. Hain, E. Oran, M. Fritts, W. Jones and J.

Gardner during the course of this work and the contributions of Elliod Dent to the programming of some of the routines in Appendix B.

REFERENCES AND FOOTNOTES

1. J.P. Boris, "Requirements for a 'Slow-Flow' Algorithm to Simulate Chemically Reacting Flows," Presented at the Symposium on Reaction Mechanisms, Models and Computers, ACS Meeting 20-25 March 1977, New Orleans, La.

2. W.W. Jones and J.P. Boris, "Flame and Reactive Jet Studies Using a Self-Consistent Two-Dimensional Hydrocode," *J. Phys. Chem.* **81**, p 2532 (1977).

3. F. Williams, *Combustion Theory,* (Addison-Wesley, Reading, Mass, 1964).

4. Pressure fluctuations less than or of order $\frac{1}{10}\ \frac{V^2}{C_s^2}$ relative to the constant background pressure are generally quite large enough to maintain constancy of the pressure.

5. W.W. Jones and J.P. Boris, "FLAME-A Slow-Flow Combustion Model," NRL Memorandum Report 3970, December 1978.

6. J.P. Boris and R.A. Shanny, "Parametric Studies of LINUS, An Ultra-High Magnetic Field Theta-Pinch," Proceedings of the Second Topical Conference on Pulsed High-Beta Plasmas, Garching, 3-6 July 1972. A.E. Robson, "Fundamental Requirements of a Fusion Feasibility Experiment Based on Flux Compression by a Collapsing Liner," NRL Memorandum Report 2616, July 1973.

7. D.L. Book, *et al.,* "Stabilized Imploding Liner Fusion Systems," 6th Intl. Conference on Plasma Physics and Controlled Nuclear Fusion Research, paper E-19-1, Brechtesgaden FRG, 6-13 October 1976. P.J. Turchi and A.E. Robson, "Conceptual Design of Imploding Liner Fusion Reactors," Proc. 6th Symposium on Engineering Problems in Fusion Research, San Diego, Cal., Nov. 18-21, 1975, p. 983.

8. A.E. Robson, "A Simple Model of a LINUS Fusion System with a Thick, Compressible, Resistive Liner," NRL Memorandum Report 3472, April 1977. D.L. Book and P.J. Turchi, "Effects of Finite Linear Compressibility in Rotationally Stabilized Liquid-liner Fusion Systems," *Comments on Plasma Physics and Controlled Fusion,* **IV(4),** p. 101, 1978.

9. J.H. Gardner, T.R. Young, J.P. Boris, "Interaction of Shocks in Hollow Pellets with Void Interface," B.A.P.S. 23(7), paper 4R11, September 1978.

10. F.H. Harlow and A.A. Amsden, "A Numerical Fluid Dynamics Calculation Method for All Flow Speeds," *Journal of Computational Physics,* **8,** p. 197 (1971).

11. D.F. Düchs, H.P. Furth, P.H. Rutherford, "Radial Transport in Takomak Discharges," in *Plasma Physics and Controlled Nuclear Fusion Research 1971, Vol. I,* proceedings of the 4th Intl. Conference on Plasma Physics and Controlled Nuclear Fusion Research, IAEA, Madison, Wisconsin, 17-23 June 1971.

12. Carl M. Lund, "HCT — A General Computer Program for Calculating Time-Dependent Phenomena Involving One-Dimensional Hydrodynamics, Transport, and Detailed Chemical Kinetics," LLL Report UCRL-52504, August 1978.

13. H.W. Bloomberg, J.P. Boris, and B. Hui, "Impurity Transport in Cylindrical Plasmas," NRL Memorandum Report 3155, November 1975.

14. D.L. Book, J.P. Boris, and K.L. Hain, "Flux-Corrected Transport I: SHASTA, A Fluid Transport Algorithm that Works," *J. Comp. Phys.* **11**, p. 38 (1973), "Flux-Corrected Transport II: Generalizations of the Method," *J. Comp. Phys.* **18**, p. 248 (1975), "Flux-Corrected Transport III: Minimal Error FCT Algorithms," *J. Comp. Phys.*

15. J.P. Boris and D.L. Book, Solution of Continuity Equations by the Method of Flux-Corrected Transport, *Chap II,* **Vol. 16**, Methods of Computational Physics (Academic Press, New York).

16. J.P. Boris, "Flux-Corrected Transport Modules for Solving Generalized Continuity Equations," NRL Memorandum Report 3237, March 1976.

17. E.S. Oran, T.R. Young and J.P. Boris, "Application of Time Dependent Numerical Methods to the Description of Reactive Shocks," *Combustion and Flame*, Proceedings of the 17th International Combustion Symposium, published 1979, also NRL Memorandum Report 3889, November 1978.

18. J.P. Boris and E.S. Oran, "Detailed Modelling of Reactive Flows," Proceedings of the GAMNI International Congress, Ecole Polytechnique, Paris, 1978.

19. M.J. Fritts and J.P. Boris, "Solution of Transient Problems in Free Surface Hydrodynamics," *Journal of Computational Physics*, accepted for publication.

20. M.J. Fritts, "Lagrangian Simulations of the Kelvin-Helmholtz Instability," Science Application Inc. Report SAI-76-632-WA, September 1976.

21. J.H. Orens, "Accurate Analytic Approximations for the Structure of Quasi-Static Laser-Driven Ablation Layers," NRL Memorandum Report , April 1979, for publication.

Appendix A
THE ADINC PACKAGE SUBROUTINES

```
      SUBROUTINE ADINC (RAD, VEL, RHO, PRE, N, DTIN, CYCLE,
     1                  RRNEW, RLNEW, VRNEW, VLNEW)
C
C
C        ADINC HAS BEEN CONSTRUCTED AS A UTILITY PACKAGE TO ADVANCE THE
C     FOUR HYDRODYNAMIC VARIABLES..
C
C     RAD(I)        = POSITION (RADIUS) OF THE I-TH CELL INTERFACE (CM)
C     VEL(I)        = VELOCITY OF THE I-TH CELL INTERFACE (CM/SEC)
C     RHO(I)        = DENSITY IN CELL I BETWEEN INTERFACES I,I+1 (GM/CC)
C     PRE(I)        = PRESSURE IN THE I-TH COMPUTATIONAL CELL (ERG/CC)
C
C     LAGRANGIAN FLUID DYNAMICS EQUATIONS ARE SOLVED INCLUDING A FLEX-
C     IBLE EQUATION OF STATE WHICH CAN VARY FROM CELL TO CELL IN THE
C     DISCRETIZED REPRESENTATION OF THE FLUID. THE EQUATIONS SOLVED ARE
C
C         D(RAD)                  D(VEL)      - 1
C         ------  =  VEL,         ------  =  ----- GRAD (PRE),
C           DT                      DT        RHO
C
C     AND THE EQUATION OF STATE ..
C
C                                ( PRE ) ** 1/GAMMAC
C         RHO  =  RHOC  +        (-----)
C                                ( ENTC).
C
C     ALL NON-IDEAL EFFECTS WHICH MIGHT BE INCLUDED IN AN ADINC CALCU-
C     LATION HAVE TO BE INCLUDED SEPARATELY EITHER BY PHENOMENOLOGICALLY
C     IMBEDDING A SIMPLE MODEL IN THE CALCULATION OR BY TIMESTEP
C     SPLITTING.
C
C        EACH FULLY LAGRANGIAN CELL HAS SEVERAL QUANTITIES THAT ARE
C     CONSERVED MOVING WITH THE FLUID AS LONG AS DIFFUSIVE AND OTHER
C     NON-IDEAL EFFECTS AND SOURCE TERMS ARE NOT INCLUDED IN THE CALCU-
C     LATION. THE EQUATION OF STATE IN EACH FLUID CELL MAY DIFFER.
C     THE QUANTITIES INVOLVED IN THE EQUATION OF STATE ARE INITIALIZED
C     BY THE TWO ENTRIES SETMAT AND SETEOS AND THE EQUATION OF STATE IS
C     EVALUATED BY CALLING USEEOS. THE EQUATION OF STATE QUANTITIES
C     ARE COMMUNICATED THROUGHOUT THE ADINC PACKAGE IN COMMON BLOCK
C     /ADICOM/. THESE "CONSTANTS" VARY FROM CELL TO CELL ACCORDING TO
C     THE INITIAL CONDITIONS. FOLLOWING ARE THE DEFINITIONS OF THESE
C     QUANTITIES..
C
C     MATERC(I)     = CELL IDENTIFIER = L.MM WHERE 0 < L < 10 IS THE
C                                       LAYER NUMBER AND 0 < MM < 100 IS
C                                       THE MATERIAL IDENTIFIER.
C     MASSC(I)      = CELL MASS = RHO(I)*LAM(I) - HELD CONSTANT IN ADINC
C     GAMMAC(I)     = CELL ADIABATIC GAS CONSTANT - HELD FIXED IN ADINC
C     ENTC(I)       = CELL ENTROPY - CONSTANT DURING ADINC HYDRODYNAMICS
C     RHOC(I)       = DENSITY CONSTANT IN THE EQUATION OF STATE (GM/CC)
```

```
C     NCELLS        = NUMBER OF CELLS OF FLUID IN THE CALCULATION
C
C         VARIABLE GAMMA AND ENTROPY ARE USED IN EACH LAGRANGIAN CELL.
C     AN IMPLICIT PRESSURE ITERATION ENSURES LINEAR STABILITY BUT HIGH
C     FREQUENCY PHENOMENA ARE INACCURATELY INTEGRATED WHEN THE TIMESTEPS
C     ARE CHOSEN TO BE APPRECIABLY LONGER THAN THE COURANT TIMESTEP. THE
C     NONLINEAR TERMS ARE ITERATED WITH A QUADRATICALLY CONVERGENT ALGO-
C     RITHM. REFERENCE: NRL MEMORANDUM REPORT #????, 1979.
C
C         PROBLEMS IN ONE OF FOUR GEOMETRIES CAN BE SET UP FOR ADINC BY
C     CHANGING THE INTEGER ALPHA IN THE CALL TO SETGEO...
C
C     ALPHA = 1     CARTESIAN COORDINATES.
C     ALPHA = 2     CYLINDRICAL COORDINATES.
C     ALPHA = 3     SPHERICAL COORDINATES.
C     ALPHA = 4     POWER SERIES COORDINATES.
C
C     ADINC USES THE UTILITY USEGEO TO DETERMINE THE INSTANTANEOUS GRID
C     QUANTITIES. CALL USEGEO CALCULATES THE INTERFACE AREAS, THE CELL
C     VOLUMES, AND THE CELL CENTER POSITIONS. ADINC DOES NOT UPDATE ALL
C     THE GEOMETRY QUANTITIES AUTOMATICALLY ON EXIT. THUS USEGEO MUST
C     ALSO BE CALLED EXTERNALLY. IN GENERAL ADINC DOES NOT HAVE ACCESS
C     TO THE USER-DEFINED ARRAYS FOR AREA, RADC, AND LAMC.
C
C         THE BOUNDARY CONDITIONS TREATED BY ADINC ARE QUITE GENERAL.
C     THE POSITIONS AND VELOCITIES OF THE REGION BOUNDING INTERFACES
C     RAD(1) AND RAD(N+1) CAN BE EXTERNALLY DETERMINED FUNCTIONS OF TIME
C     AND OTHER PHYSICAL VARIABLES DURING THE CALCULATION. THE BOUNDARY
C     CONDITIONS ARE COMMUNICATED TO THE ADINC PACKAGE VIA THE FOUR
C     ARGUMENTS...
C
C     RRNEW         = RIGHT BOUNDARY POSITION RAD(N+1) AT END OF TIMESTEP
C     RLNEW         = LEFT BOUNDARY POSITION RAD(1) AT END OF TIMESTEP
C     VRNEW         = RIGHT BOUNDARY VELOCITY VEL(N+1) AT END OF TIMESTEP
C     VLNEW         = LEFT BOUNDARY VELOCITY VEL(1) AT END OF TIMESTEP
C
C         SEVERAL AUXILIARY VARIABLES ARE USED BY ADINC ITSELF OR THE
C     ADINC ROUTINES WHICH SHOULD ALSO BE EXPLAINED TO THE USER.
C
C     N = NCELLS    = NUMBER OF FLUID CELLS IN THE ADINC INTEGRATION
C     DTIN          = TIME INTERVAL FOR THE ADINC INTEGRATION WHICH MAY
C                     SUBCYCLE UP TO 100 TIMES INTERNALLY IF NEEDED FOR
C                     ACCURACY OR STABILITY.
C     CYCLE         = TIMESTEP NUMBER USED BY ADINC FOR IDENTIFICATION
C     EPSRO         = EXPLICITNESS PARAMETER FOR THE POSITION INTEGRATION
C     EPSVO         = EXPLICITNESS PARAMETER FOR THE VELOCITY INTEGRATION
C     NDAMP         = NUMBER OF CYCLES AT THE BEGINNING OF A CALCULATION
C                     IN WHICH ADDITIONAL DAMPING/SMOOTHING IS APPLIED.
C     EPSP          = EXPLICITNESS PARAMETER FOR RAD LAST USED BY ADINC
C     EPSV          = EXPLICITNESS PARAMETER FOR VEL LAST USED BY ADINC
C
C         THE PARAMETER NPT, HERE 202, MUST BE AT LEAST TWO LARGER THAN
C     THE NUMBER OF FINITE DIFFERENCE CELLS BEING INTEGRATED BY ADINC.
C
C
      PARAMETER     NPT = 202, MPT = 2*NPT
          INTEGER   CYCLE
          REAL*8    RAD(NPT),    VEL(NPT),    RHO(NPT),    PRE(NPT)
          REAL*8    RHOO(NPT),   RHON(NPT),   PREO(NPT),   PREN(NPT)
          REAL*8    LAMO(NPT),   LAMN(NPT),   RADCO(NPT),  RADCN(NPT)
          REAL*8    RIN(NPT),    VIN(NPT),    DLAM(NPT),   LAMEOS(NPT)
          REAL*8    RBARI(NPT),  RBAR(NPT),   RDRI(NPT),   DTORHO(NPT)
```

```
113             REAL*8   AA(NPT),     BB(NPT),     CC(NPT),     DD(NPT)
114             REAL*8   AI(NPT),     BI(NPT),     C(NPT),      DP(NPT)
115             REAL*8   DN(NPT),     SCA(NPT),    SCB(NPT),    DLAMDP(NPT)
116             REAL*8   AREAO(NPT), AREAH(NPT), AREAN(NPT)
117             REAL*8   ERRLIM,      ERRMAX,      ERROR,       AMNMAS
118             REAL*8   PREMAX,      PREMIN,      RPREMX,      DT
119             REAL*8   VRNEW,       VLNEW,       RRNEW,       RLNEW
120             REAL*8   VROLD,       VLOLD,       RROLD,       RLOLD
121             REAL*8   DVROLD,      DVLOLD,      DRROLD,      DRLOLD
122             REAL*8   EPSR,        OMEPSR,      EPSV,        OMEPSV
123             REAL*8   EPSR0,       EPSV0,       OMERDT,      AMXMAS
124             REAL*8   DTIN,        DTVAL
125   C
126   C      DECLARATIONS FOR COMMON BLOCK /ADICOM/ APPEAR THROUGHOUT THE ADINC
127   C      PACKAGE ROUTINES.
128             REAL*8   MASSC(NPT), ENTC(NPT),  RHOC(NPT),  MATERC(NPT)
129             REAL*8   GAMMAC(NPT)
130             COMMON   /ADICOM/  MATERC, MASSC, GAMMAC, ENTC, RHOC, NCELLS
131   C
132             DATA     NDAMP /10/,   EPSR, EPSV /0.0D0, 0.0D0/
133             DATA     NCALL, NITER, NTIME /0, 0, 0/
134             DATA     ERRLIM, EPSR0,EPSV0,ITEMAX/1.0D-9, 0.45D0, 0.45D0, 6/
135             EQUIVALENCE  (DTORHO(1), RDRI(1)),     (AREAH(1), AREAN(1))
136   C
137   C      ADINC FORMATS FOR DIAGNOSTIC AND ERROR PRINTS.
138    1001     FORMAT ('0ADINC TIMESTEP PROBLEM AT CYCLE', I5, '  DT = ',
139         1        1PD12.4, '  AND ITEMAX = ', I2, '  ERRLIM = ', D12.4, /,
140         2        10X, '  ERRMAX AT', I4, ' = ', D12.4, '  AND', I3,
141         3        ' CELLS NOT CONVERGED.')
142    1002     FORMAT ('0ADINC TIMESTEP PROBLEM AT CYCLE', I5, '  DTVAL = ',
143         1        1PD12.4, '  BUT DTIN = ', D12.4, '  TIMESTEP SUBCYCLED.')
144    1003     FORMAT ('0ADINC TIMESTEP PROBLEM AT CYCLE', I5, '  DTVAL = ',
145         1        1PD12.4, '  BUT DTIN = ', D12.4, '  CALCULATION STOPPED.')
146    1004     FORMAT ('0ADINC INPUT PROBLEM AT CYCLE', I5,
147         1        ' THE SYSTEM SIZE N ', I4, ' OUT OF RANGE. NPT =', I4,
148         2        ' CALCULATION STOPPED.')
149    1005     FORMAT ('0ADINC INPUT PROBLEM AT CYCLE', I5,
150         1        ' THE LEFT BOUNDARY HAS CROSSED THE RIGHT .', 1P2D12.4,
151         2        ' CALCULATION STOPPED.')
152    1006     FORMAT ('0ADINC INPUT PROBLEM AT CYCLE', I5,
153         1        ' THE CELL SIZE WAS ', 1PD12.4,' AT CELL ', I4,
154         2        ' CALCULATION STOPPED.')
155    1007     FORMAT ('0ADINC INPUT PROBLEM AT CYCLE', I5,
156         1        ' THE DENSITY MIN WAS ', 1PD12.4,' AT CELL ', I4,
157         2        ' CALCULATION STOPPED.')
158    1008     FORMAT ('0ADINC INPUT PROBLEM AT CYCLE', I5,
159         1        ' THE PRESSURE MIN WAS ', 1PD12.4,' AT CELL ', I4,
160         2        ' CALCULATION STOPPED.')
161    1009     FORMAT ('0ADINC FREQUENCY COUNTERS (SINCE LAST CHECK) AT ',
162         1        'CYCLE', I5, /, 10X, 'NO. CALLS =', I5, '    NO. TIME',
163         2        'STEPS =', I5, '    TOTAL NO. ITERATIONS =', I5, /)
164   C
165   C
166   C      CHECK THE INPUT TO ADINC FOR REASONABLENESS.
167             NPTO = NPT
168             IF ( N.LE.2 .OR. N.GT.NPT-2) WRITE (6, 1004) CYCLE, N, NPTO
169             IF ( N.LE.2 .OR. N.GT.NPT-2) STOP
170             IF (RRNEW.LE.RLNEW) WRITE (6, 1005) CYCLE, RLNEW, RRNEW
171             IF (RRNEW.LE.RLNEW) STOP
172             DO 20 I = 1, N
173       20    DM(I+1) = RAD(I+1) - RAD(I)
174             CALL MAXMIN (DM(2), N, PREMAX, IMAX, PREMIN, IMIN)
```

```
175             IF (PREMIN .LE. 0.0D0) WRITE (6, 1006) CYCLE, PREMIN, IMIN
176             IF (PREMIN .LE. 0.0D0)  STOP
177             CALL MAXMIN (RHO(2), N, PREMAX, IMAX, PREMIN, IMIN)
178             IF (PREMIN .LE. 0.0D0) WRITE (6, 1007) CYCLE, PREMIN, IMIN
179             IF (PREMIN .LE. 0.0D0)  STOP
180             CALL MAXMIN (PRE(2), N, PREMAX, IMAX, PREMIN, IMIN)
181             IF (PREMIN .LE. 0.0D0) WRITE (6, 1008) CYCLE, PREMIN, IMIN
182             IF (PREMIN .LE. 0.0D0)  STOP
183   C
184   C     ESTABLISH INTEGRATION AND CONTROL CONSTANTS FOR THIS CYCLE.
185             N1 = N + 1
186             CALL MAXMIN (MASSC(2), N, AMXMAS, IMAX, AMNMAS, IMIN)
187             ERROR = DSQRT(AMXMAS/AMNMAS)*ERRLIM
188             RROLD = RAD(N1)
189             RLOLD = RAD(1)
190             VROLD = VEL(N1)
191             VLOLD = VEL(1)
192             NCALL = NCALL + 1
193             NCALIM = MIN0 (NCALL, NDAMP)
194             EPSR = DFLOAT(NCALIM)*EPSR0/DFLOAT(NDAMP)
195             EPSV = DFLOAT(NCALIM)*EPSV0/DFLOAT(NDAMP)
196             OMEPSR = 1.0D0 - EPSR
197             OMEPSV = 1.0D0 - EPSV
198   C
199   C     CHECK THE TIMESTEP FOR SUBCYCLING AND NOTE ANY PROBLEMS.
200             CALL DTFLOW (RAD, VEL, DTVAL, N)
201             NSTEP = 1
202             DT = DTIN
203             IF (DTVAL .GT. DTIN) GO TO 40
204             IF (DTVAL .LT. 0.01D0*DTIN) GO TO 30
205             WRITE (6, 1002) CYCLE, DTVAL, DTIN
206             NSTEP = (DTIN + DTVAL)/DTVAL
207             DT = DTIN/FLOAT(NSTEP)
208             GO TO 40
209       30    WRITE (6, 1003) CYCLE, DTVAL, DTIN
210             STOP
211   C
212   C     INITIALIZE VARIABLES FOR THE SUBCYCLING AND ITERATIONS.
213       40    DVROLD = (VRNEW - VROLD)/FLOAT(NSTEP)
214             DVLOLD = (VLNEW - VLOLD)/FLOAT(NSTEP)
215             DRROLD = (RRNEW - RROLD)/FLOAT(NSTEP)
216             DRLOLD = (RLNEW - RLOLD)/FLOAT(NSTEP)
217             DO 50 I = 2, N
218             RIN(I) = RAD(I) + DT*VEL(I)
219       50    VIN(I) = VEL(I)
220             RIN(1) = RLOLD + DRLOLD
221             RIN(N1) = RROLD + DRROLD
222             VIN(1) = VLOLD + DVLOLD
223             VIN(N1) = VROLD + DVROLD
224             DO 55 I = 2, N1
225             PREO(I) = PRE(I)
226       55    PREN(I) = PRE(I)
227             CALL USEGEO (RAD, AREAO, RADCO, LAMO, N)
228             CALL USEEOS (RHOO, PREO, LAMEOS, DLAMDP, N)
229             CALL USEGEO (RIN, AREAN, RADCN, LAMN, N)
230             CALL USEEOS (RHON, PREN, LAMEOS, DLAMDP, N)
231             RPREMX = 1.0D0/PREMAX
232             DO 60 I = 2, N1
233       60    PRE(I) = 0.0D0
234   C
235   C     PERFORM TIMESTEP SUBCYCLING
236             DO 550 ISTEP = 1, NSTEP
```

```
237                NTIME = NTIME + 1
238   C
239   C       PERFORM THE ITERATION FOR NEW VALUES RHON, LAMN, PREN, RIN AND VIN
240                DO 500 ITER = 1, ITEMAX
241                NITER = NITER + 1
242   C
243   C       CALCULATE QUANTITIES USED IN TRIDIAGONAL EXPRESSIONS.
244                DO 200 I = 1, N1
245                AREAH(I) = 0.5D0*(AREAO(I) + AREAN(I))
246      200       RBARI(I) = 0.5D0*(RAD(I) + RIN(I))
247                DO 205 I = 2, N1
248                DLAM(I) = LAMBOS(I) - LAMN(I)
249      205       RBAR(I) = 0.5D0*(RADCO(I) + RADCN(I))
250                DO 210 I = 2, N
251                RDRI(I) = RHON(I)*(RBARI(I) - RBAR(I)) + RHON(I+1)*(RBAR(I+1)
252           1                - RBARI(I))
253      210       DTORHO(I) = DT/RDRI(I)
254   C
255   C       CALCULATE EXPRESSIONS USED IN THE TRIDIAGONAL COEFFICIENTS.
256                OMERDT = -OMEPSR*DT
257                DO 250 I = 2, N
258                AI(I) = VEL(I) - DTORHO(I)*EPSV*(PREO(I+1) - PREO(I))
259      250       BI(I) = DTORHO(I)*OMEPSV
260                DO 260 I = 2, N1
261                DP(I) = OMERDT*AREAH(I)
262                DM(I) = OMERDT*AREAH(I-1)
263                C(I) = PREN(I)*DLAMDP(I) + DP(I)*VIN(I) - DM(I)*VIN(I-1)
264      260       C(1) = C(I) -DLAM(I)
265   C
266   C       CALCULATE THE TRIDIAGONAL COEFFICIENTS WITH BOUNDARY CONDITIONS.
267                DO 300 I = 2, N1
268                DD(I) = C(I)
269      300       BB(I) = DLAMDP(I)
270                DO 305 I = 2, N
271                CC(I) = -DP(I)*BI(I)
272                AA(I+1) = -DM(I+1)*BI(I)
273                BB(I) = BB(I) - CC(I)
274      305       DD(I) = DD(I) - DP(I)*AI(I)
275                DO 310 I = 3, N1
276                BB(I) = BB(I) - AA(I)
277      310       DD(I) = DD(I) + DM(I)*AI(I-1)
278                DD(2) = DD(2) + DM(2)*VLNEW
279                DD(N1) = DD(N1) - DP(N1)*VRNEW
280                AA(2) = 0.0D0
281                CC(N1) = 0.0D0
282   C
283   C       SOLVE THE TRIDIAGONAL SYSTEM AND CONSTRUCT THE NEW VALUES AT TIME
284   C       T + DT FOR THE CURRENT ITERATION. TRIDDV FAILS WHEN N < 15 THUS
285   C       TRIDDS, THE SCALAR VERSION, IS USED IN THIS REGIME INSTEAD.
286                IF (N .LT. 15) CALL TRIDDS (N, AA(2), BB(2), CC(2), DD(2),
287           1         PREN(2), SCA(2), SCB(2))
288                IF (N .GE. 15) CALL TRIDDV (N, AA(2), BB(2), CC(2), DD(2),
289           1         PREN(2), SCA(2), SCB(2))
290   C
291   C       IN SOME CIRCUMSTANCES IT MAY BE APPROPRIATE TO LET THE PRESSURE GO
292   C       NEGATIVE. IN SUCH CASES THE FOLLOWING LOOP MUST BE REMOVED OR
293   C       PREMIN MUST BE ALLOWED TO GO NEGATIVE.
294                DO 340 I = 2, N1
295      340       PREN(I) = DMAX1 (0.01D0*PREMIN, PREN(I))
296                DO 350 I = 2, N
297                VIN(I) = AI(I) - BI(I)*(PREN(I+1) - PREN(I))
298      350       RIN(I) = RAD(I) + DT*(EPSR*VEL(I) + OMEPSR*VIN(I))
```

```
299               CALL USEGEO (RIN, AREAN, RADCN, LAMN, N)
300               CALL USEEOS (RHON, PREN, LAMEOS, DLAMDP, N)
301   C
302   C       CHECK ON WHETHER THE ITERATION HAS CONVERGED.
303               DO 400 I = 2, N1
304               SCA(I) = PREN(I) - PRE(I)
305               SCA(I) = DABS(SCA(I))*RPREMX
306               SCB(I) = EPSOR
307     400       PRE(I) = PREN(I)
308               NOTCON = 0
309               ICELL = 0
310               ERRMAX = 0.000
311               DO 405 I = 2, N1
312               IF (SCA(I) .LT. SCB(I)) GO TO 405
313               NOTCON = NOTCON + 1
314               IF (SCA(I) .GT. ERRMAX) ICELL = I
315               ERRMAX = DMAX1 (ERRMAX, SCA(I))
316     405       CONTINUE
317               IF (NOTCON .EQ. 0) GO TO 505
318   C
319     500       CONTINUE
320   C
321   C       PRINT OUT IF WE HAVE NOT CONVERGED.
322               IF (MOD(CYCLE, 10) .EQ. 0)
323          1    WRITE (6, 1001) CYCLE, DT, ITEMAX, EPSOR, ICELL, ERRMAX,
324          2         NOTCON
325     505       CONTINUE
326   C
327   C       SET UP FOR ANOTHER SUBCYCLE TIMESTEP.
328               IF (ISTEP .EQ. NSTEP) GO TO 550
329               DO 520 I = 1, N1
330               AREA0(I) = AREAN(I)
331               VEL(I) = VIN(I)
332     520       RAD(I) = RIN(I)
333               DO 525 I = 1, N1
334               RIN(I) = RAD(I) + DT*VEL(I)
335     525       VIN(I) = VEL(I)
336               RIN(1) = RAD(1) + DRLOLD
337               RIN(N1) = RAD(N1) + DRROLD
338               VIN(1) = VEL(1) + DVLOLD
339               VIN(N1) = VEL(N1) + DVROLD
340               DO 530 I = 2, N1
341               RHO(I) = RHON(I)
342               PRE0(I) = PRE(I)
343     530       RHO0(I) = RHON(I)
344               CALL USEGEO (RIN, AREAN, RADCN, LAMN, N)
345               CALL USEEOS (RHON, PREN, LAMEOS, DLAMDP, N)
346     550       CONTINUE
347   C
348   C       CLEAN UP FOR EXIT.
349               DO 600 I = 1, N1
350               VEL(I) = VIN(I)
351     600       RAD(I) = RIN(I)
352               DO 601 I = 2, N1
353     601       RHO(I) = RHON(I)
354               RETURN
355   C
356   C
357               ENTRY ADINC0 (NOLE, CYCLE)
358   C       ----------
359   C
360   C       ADINC0 PRINTS OUT THE NUMBER OF CALLS TO ADINC, THE NUMBER OF
```

```
      C     TIMESTEPS INCLUDING SUBCYCLING PERFORMED BY ADINC DURING THOSE
      C     CALLS, AND THE TOTAL NUMBER OF ITERATIONS PERFORMED SINCE THE LAST
      C     CALL TO ADINCO.
      C
      C     MODE = 0      PRINT OUT AND RESET THE COUNTERS IN ADINC.
      C     MODE .NE. 0   RESET ALL BUT NCALL COUNTER FOR FILTERING OPERATION
      C     CYCLE         = TIMESTEP NUMBER FOR IDENTIFICATION PURPOSES
      C
            WRITE (6, 1009) CYCLE, NCALL, NTIME, NITER
            IF (MODE .EQ. 0) NCALL = 0
            NTIME = 0
            NITER = 0
            RETURN
      C
      C
            ENTRY SETEPS (ER0, EV0, MDAMP, EROUT, EVOUT)
      C     --------------
      C
      C     SETEPS PERMITS THE USER TO RESET THE EXPLICITNESS PARAMETERS FOR
      C     DIFFERENT TYPES OR STAGES OF FLUID PROBLEMS. THE EXPLICITNESS
      C     PARAMETERS ARE MAPPED INTO THE RANGE 0 <= EPS <= 1.
      C
      C     ER0           = THE NEW POSITION EXPLICITNESS PARAMETER
      C     EV0           = THE NEW VELOCITY EXPLICITNESS PARAMETER
      C     MDAMP         = THE NEW VALUE OF NDAMP, # OF DAMPING CYCLES
      C     EROUT         = THE MOST RECENT POSITION EXPLICITNESS PARAMETER
      C     EVOUT         = THE MOST RECENT VELOCITY EXPLICITNESS PARAMETER
      C
            REAL*8   ER0, EV0, EROUT, EVOUT
      C
            NDAMP = MAX0 (MDAMP, 1)
            EPSR0 = DMIN1 (ER0, 1.0D0)
            EPSV0 = DMIN1 (EV0, 1.0D0)
            EPSR0 = DMAX1 (EPSR0, 0.0D0)
            EPSV0 = DMAX1 (EPSV0, 0.0D0)
            EROUT = EPSR
            EVOUT = EPSV
            RETURN
            END
```

```
      SUBROUTINE SETGEO (ALPHA, GEOMCO)
C
C
C         SETGEO CONTROLS THE GEOMETRIC ASPECTS OF AN ADINC INTEGRATION.
C     SETGEO IS CALLED BY THE USER TO TELL THE ADINC PACKAGE EXACTLY
C     WHICH OF THE FOUR POSSIBLE GEOMETRIES HE WISHES TO USE.
C
C     ALPHA = 1     CARTESIAN COORDINATES.
C     ALPHA = 2     CYLINDRICAL COORDINATES.
C     ALPHA = 3     SPHERICAL COORDINATES.
C     ALPHA = 4     POWER SERIES COORDINATES.
C     GEOMCO(1..5) = ARRAY OF FIVE COEFFICIENTS IN THE EXPRESSION FOR
C                    CELL AREA AND INTEGRATED VOLUME USED BELOW.
C
C     SETGEO INITIALIZES THE QUANTITIES GALPHA, HALPHA, G(I), AND H(I)
C     FOR LATER REPEATED USE IN ENTRY USEGEO BELOW.
C
          PARAMETER  NPT = 202
          INTEGER  ALPHA,      ALPHH
          REAL*8   GALPHA,     HALPHA,     G(5),       H(5)
          REAL*8   GEOMCO(5),  RIAM1(NPT), DELR(NPT),  TVOL(NPT)
          REAL*8   DTMIN(NPT), ABSV(NPT),  DRMIN,      PI
          EQUIVALENCE  (DTMIN(1), TVOL(1)),  (ABSV(1), DELR(1))
          EQUIVALENCE  (RIAM1(1), TVOL(1))
C
C     CHECK THE INPUT TO SETGEO AND INITIALIZE.
          IF (ALPHA.LT.1 .OR. ALPHA.GT.4) WRITE (6, 1001) ALPHA, GEOMCO
          IF (ALPHA.LT.1 .OR. ALPHA.GT.4) STOP
 1001     FORMAT ('0SETGEO INPUT PROBLEM. ALPHA OUT OF RANGE. ',
     1         I4, 2X, 1P5D12.4)
          PI = 3.14159265358979D0
          ALPHH = ALPHA
          GO TO (10, 20, 30, 40), ALPHH
C
C     MODE = 1      RESET ADINC FOR CARTESIAN COORDINATES.
   10     GALPHA = 1.0D0
          HALPHA = 1.0D0
          RETURN
C
C     MODE = 2      RESET ADINC FOR CYLINDRICAL COORDINATES.
   20     GALPHA = PI
          HALPHA = 2.0D0*PI
          RETURN
C
C     MODE = 3      RESET ADINC FOR SPHERICAL COORDINATES.
   30     GALPHA = 4.0D0*PI/3.0D0
          HALPHA = 4.0D0*PI
          RETURN
C
C     MODE = 4      RESET ADINC FOR POWER SERIES COORDINATES.
   40     DO 41 I = 1, 5
          G(I) = GEOMCO(I)
   41     H(I) = G(I)/DFLOAT(I)
          RETURN
C
C
          ENTRY USEGEO (RAD, AREA, RADC, LAMC, N)
C     ---------------
C
C     GIVEN A MONOTONICALLY INCREASING SET OF CELL INTERFACE POSITIONS,
C     THE INTERFACE AREAS, CELL CENTER LOCATIONS, AND CELL VOLUMES ARE
C     CALCULATED IN A FULLY VECTORIZED MANNER. THIS GEOMETRIC UTILITY
```

```
C      IS USED BY ADINC, DIAGNOSTICS ROUTINES AND THE MAIN PROGRAM -
C      WHENEVER THE CELL INTERFACE CONFIGURATION IS CHANGED - TO UPDATE
C      THE GEOMETRIC QUANTITIES.
C
C      RAD(I)        = POSITION OF THE I-TH INTERFACE (I = 1, N+1) (CM)
C      AREA(I)       = AREA IN THE COMPUTATIONAL DOMAIN OF THE I-TH CELL
C                      INTERFACE (CM**2)
C      RADC(I)       = POSITION OF THE I-TH CELL CENTER (I = 2, N+1) (CM)
C      LAMC(I)       = VOLUME OF CELL I BETWEEN INTERFACES I, I+1. (CM**3)
C      N             = NUMBER OF INTERIOR CELLS IN THE SYSTEM
C
          REAL*8   RAD(NPT),   AREA(NPT),  RADC(NPT),  LAMC(NPT)
C
C
C      CHECK THE INPUT TO USEGEO FOR REASONABLENESS.
          NPTO = NPT
          IF (N.LE.1 .OR. N.GT.NPT-2) WRITE (6, 1002) N, NPTO
          IF (N.LE.1 .OR. N.GT.NPT-2) STOP
          DO 50 I = 1, N
   50     TVOL(I+1) = RAD(I+1) - RAD(I)
          CALL MAXMIN (TVOL(2), N, TVOL(1), IMAX, DRMIN, IMIN)
          IF (DRMIN .LE. 0.0D0) WRITE (6, 1003) DRMIN, IMIN
          IF (DRMIN .LE. 0.0D0) STOP
 1002     FORMAT ('0USEGEO INPUT PROBLEM. N OUT OF RANGE. ',  I4, I4,
     1         ' CALCULATION STOPPED.')
 1003     FORMAT ('0USEGEO INPUT PROBLEM. CELL SIZE NEGATIVE ',
     1         1PD12.4, ' AT CELL ', I4, '  CALCULATION STOPPED.')
C
          NP = N + 1
          GO TO (100, 200, 300, 400), ALPHH
C
  100     DO 101 I = 1, NP
  101     RIAM1(I) = 1.0D0
          GO TO 500
C
  200     DO 201 I = 1, NP
  201     RIAM1(I) = RAD(I)
          GO TO 500
C
  300     DO 301 I = 1, NP
  301     RIAM1(I) = RAD(I)*RAD(I)
C
C      FOR THE REGULAR GEOMETRIES CALCULATE THE AREA AND VOLUME.
  500     DO 501 I = 1, NP
          AREA(I) = HALPHA*RIAM1(I)
  501     TVOL(I) = GALPHA*RIAM1(I)*RAD(I)
          GO TO 600
C
C      FOR THE POWER SERIES (NOZZLE) COORDINATES THE USER MUST SPECIFY
C      ALL OF THE GEOMETRIC COEFFICIENTS VIA THE INITIALIZING ARRAY
C      GEOMCO IN THE CALL TO SETGEO. HERE G(1) = GEOMCO(1), ETC.
C      AREA(R) = G1 + G2*R + G3*R**2 + G4*R**3 + G5*R**4
C      TVOL(R) = H1*R + H2*R**2 + H3*R**3 + H4*R**4 + H5*R**5
  400     DO 401 I = 1, NP
          AREA(I) = G(5)*RAD(I)
          TVOL(I) = H(5)*RAD(I)
          AREA(I) = RAD(I)*(AREA(I) + G(4))
          TVOL(I) = RAD(I)*(TVOL(I) + H(4))
          AREA(I) = RAD(I)*(AREA(I) + G(3))
          TVOL(I) = RAD(I)*(TVOL(I) + H(3))
          AREA(I) = RAD(I)*(AREA(I) + G(2))
          TVOL(I) = RAD(I)*(TVOL(I) + H(2))
```

```
125               AREA(I) = AREA(I) + G(1)
126     401       TVOL(I) = RAD(I)*(TVOL(I) + H(1))
127     C
128     C      COMPUTE THE CELL VOLUME AND CELL CENTER LOCATIONS.
129       600     CALL MAXMIN (AREA(1), NP, RADC(1), IMAX, DRMIN, IMIN)
130               IF (DRMIN .LE. 0.0D0) WRITE (6, 2001) DRMIN, IMIN
131               IF (DRMIN .LE. 0.0D0) STOP
132      2001     FORMAT ('0USERGEO PROBLEM, NEGATIVE AREA ', 1PD12.4,
133         1         ' AT CELL ', I4, ' CALCULATION STOPPED.')
134               DO 601 I = 2, NP
135               LAMC(I) = TVOL(I) - TVOL(I-1)
136       601     RADC(I) = (RAD(I)*AREA(I-1) + RAD(I-1)*AREA(I))/
137          1         (AREA(I) + AREA(I-1))
138               RETURN
139     C
140     C
141               ENTRY DTFLOW (ROD, VEL, DTVAL, N)
142     C         ----------
143     C
144     C      DTFLOW CALCULATES A PERMISSIBLE TIMESTEP DTVAL GIVEN THE SET OF
145     C      N + 1 CELL INTERFACES AND THEIR VELOCITIES.
146     C
147     C      ROD(I)          = POSITION OF THE I-TH CELL INTERFACE (CM)
148     C      VEL(I)          = VELOCITY OF THE I-TH CELL INTERFACE (CM/SEC)
149     C      DTVAL           = THE ESTIMATED VALUE OF A PERMISSIBLE TIMESTEP WHICH
150     C                        PREVENTS INTERFACE CROSSING ASSUMING THE MOTION GIVEN
151     C      N               = THE NUMBER OF INTERIOR CELLS IN THE CURRENT SYSTEM
152     C
153               REAL*8    ROD(N), VEL(N), DTVAL, EPS, DVSAFE, DTMAX
154     C
155     C
156     C      CHECK THE INPUT TO DTFLOW FOR REASONABLENESS.
157               NPTO = NPT
158               IF (N.LE.2 .OR. N.GT.NPT-2) WRITE (6, 1004) N, NPTO
159               IF (N.LE.2 .OR. N.GT.NPT-2) STOP
160               N1 = N + 1
161               EPS = 0.49D0
162               DO 715 I = 2, N1
163       715     DELR(I) = ROD(I) - ROD(I-1)
164               CALL MAXMIN (DELR(2), N, DELR(1), IMAX, DRMIN, IMIN)
165               IF (DRMIN .LE. 0.0D0) WRITE (6, 1005) DRMIN, IMIN
166               IF (DRMIN .LE. 0.0D0) STOP
167      1004     FORMAT ('0DTFLOW INPUT PROBLEM. N OUT OF RANGE. ',  I4, I4,
168         1         ' CALCULATION STOPPED.')
169      1005     FORMAT ('0DTFLOW INPUT PROBLEM. CELL SIZE NEGATIVE ',
170         1         1PD12.4, ' AT CELL ', I4, '  CALCULATION STOPPED.')
171     C
172     C      REQUIRE VEL*DT < MINIMUM OF CELL WIDTHS DELR.
173               DO 720 I = 2, N
174       720     DTMIN(I) = EPS*DMIN1(DELR(I), DELR(I+1))
175               DTMIN(1) = DELR(2)
176               DTMIN(N1) = DELR(N1)
177               DO 725 I = 1, N1
178       725     ABSV(I) = DABS(VEL(I))
179               DVSAFE = 1.0D-40
180               DO 730 I = 1, N1
181       730     DTMIN(I) = DTMIN(I)/(ABSV(I) + DVSAFE)
182               CALL MAXMIN (DTMIN, N1, DTMAX, IMAX, DTVAL, IMIN)
183               RETURN
184           END
```

```
      SUBROUTINE SETMAT (MATER, MASS, GAMMA, RHOCON, N)
C
C         THIS ROUTINE PROVIDES A VECTORIZED DOUBLE PRECISION EQUATION
C     OF STATE CALCULATION FOR ADINC. WHEN THE EQUATION OF STATE IS
C     CHANGED, A NUMBER OF OTHER ROUTINES MUST BE MODIFIED AS WELL.
C
C     EQUATION OF STATE ...      PRE = RHOC * (PRE/ENTC)**(1/GAMMAC).
C     MATER(I)      = CELL IDENTIFIER = L.MM WHERE 0 < L < 10 IS THE
C                                       LAYER NUMBER AND 0 < MM < 100 IS
C                                       THE MATERIAL IDENTIFIER.
C     MASSC(I)      = CELL MASS = RHO(I)*LAM(I)
C     GAMMAC(I)     = CELL ADIABATIC GAS CONSTANT - FIXED DURING ADINC
C     ENTC(I)       = CELL ENTROPY - CONSTANT DURING ADINC HYDRODYNAMICS
C     RHOC(I)       = DENSITY CONSTANT IN THE EQUATION OF STATE
C
          PARAMETER    NPT = 202
          REAL*8    DELR(NPT),   DELV(NPT),   DRMAX,       DRMIN
          REAL*8    MATER(NPT), MASS(NPT),   GAMMA(NPT), RHOCON(NPT)
          REAL*8    MASSC(NPT), ENTC(NPT),   RHOC(NPT),   MATERC(NPT)
          REAL*8    GAMMAC(NPT),               DELRHO(NPT)
          COMMON    /ADICOM/  MATERC, MASSC, GAMMAC, ENTC, RHOC, NCELLS
C
C
C     CHECK THE INPUT TO SETMAT FOR REASONABLENESS.
          NPTO = NPT
          IF (N.LE.2 .OR. N.GT.NPT-2) WRITE (6, 1001) N, NPTO
          IF (N.LE.2 .OR. N.GT.NPT-2) STOP
          CALL MAXMIN (MATER(2), N, DRMAX, IMAX, DRMIN, IMIN)
          IF (DRMIN .LE. 0.0D0) WRITE (6, 1002) DRMIN, IMIN
          IF (DRMIN .LE. 0.0D0) STOP
          CALL MAXMIN (MASS(2), N, DRMAX, IMAX, DRMIN, IMIN)
          IF (DRMIN .LE. 0.0D0) WRITE (6, 1003) DRMIN, IMIN
          IF (DRMIN .LE. 0.0D0) STOP
          CALL MAXMIN (RHOCON(2), N, DRMAX, IMAX, DRMIN, IMIN)
          IF (DRMIN .LT. 0.0D0) WRITE (6, 1004) DRMIN, IMIN
          IF (DRMIN .LT. 0.0D0) STOP
 1001     FORMAT ('0SETMAT INPUT PROBLEM. N OUT OF RANGE. ',  I4, I4,
     1         ' CALCULATION STOPPED.')
 1002     FORMAT ('0SETMAT INPUT PROBLEM. CELL MATERIAL NEGATIVE ',
     1         1PD12.4, ' AT CELL ', I4, '  CALCULATION STOPPED.')
 1003     FORMAT ('0SETMAT INPUT PROBLEM. CELL MASS NEGATIVE ',
     1         1PD12.4, ' AT CELL ', I4, '  CALCULATION STOPPED.')
 1004     FORMAT ('0SETMAT INPUT PROBLEM. CELL RHOCON NEGATIVE ',
     1         1PD12.4, ' AT CELL ', I4, '  CALCULATION STOPPED.')
C
          NP = N + 1
          DO 100 I = 2, NP
          MATERC(I) = MATER(I)
          MASSC(I) = MASS(I)
          GAMMAC(I) = GAMMA(I)
  100     RHOC(I) = RHOCON(I)
          NCELLS = N
          RETURN
C
C
          ENTRY SETEOS (RHO, PRE, N)
C         ----------
C
C     SETEOS COMPUTES THE ENTROPY CELL CONSTANTS (ENTC) GIVEN KNOWN
C     VALUES OF THE DENSITY AND PRESSURE IN THE CELLS. SETEOS IS USED
C     AT THE BEGINNING OF CALCULATIONS FOR INITIALIZATION AND DURING
C     CALCULATIONS WHENEVER NON-IDEAL, SOURCE, OR DISSIPATIVE EFFECTS
```

```
C     HAVE CHANGED THE CELL ENTROPIES. SINCE ADINC IS PREDICATED ON THE
C     CONSTANCY OF THE LAGRANGIAN CELL ENTROPY DURING A FLUID TIMESTEP,
C     THIS AMOUNTS TO A FORM OF TIMESTEP SPLITTING.
C
C     RHO(I)        = DENSITY OF MATERIAL IN CELL I (I = 2, N+1) (GM/CC)
C                     THESE QUANTITIES ARE GIVEN AS INPUTS TO SETEOS
C     PRE(I)        = PRESSURE GIVEN IN CELL I BETWEEN INTERFACES I AND
C                     I-1.  THESE VALUES ARE INPUT TO SETEOS (ERG/CC)
C     N             = NUMBER OF INTERIOR CELLS IN THE SYSTEM
C
          REAL*8   RHO(NPT),   PRE(NPT)
C
C
C     CHECK THE INPUT TO SETEOS FOR REASONABLENESS.
          NPTO = NPT
          IF (N.LE.2 .OR. N.GT.NPT-2) WRITE (6, 1005) N, NPTO
          IF (N.LE.2 .OR. N.GT.NPT-2) STOP
          CALL MAXMIN (RHO(2), N, DRMAX, IMAX, DRMIN, IMIN)
          IF (DRMIN .LE. 0.0D0) WRITE (6, 1006) DRMIN, IMIN
          IF (DRMIN .LE. 0.0D0) STOP
          CALL MAXMIN (PRE(2), N, DRMAX, IMAX, DRMIN, IMIN)
          IF (DRMIN .LE. 0.0D0) WRITE (6, 1007) DRMIN, IMIN
          IF (DRMIN .LE. 0.0D0) STOP
 1005     FORMAT ('0SETEOS INPUT PROBLEM. N OUT OF RANGE. ',  I4, I4,
     1         ' CALCULATION STOPPED.')
 1006     FORMAT ('0SETEOS INPUT PROBLEM. CELL DENSITY NEGATIVE ',
     1         1PD12.4, ' AT CELL ', I4, '  CALCULATION STOPPED.')
 1007     FORMAT ('0SETEOS INPUT PROBLEM. CELL PRESSURE NEGATIVE ',
     1         1PD12.4, ' AT CELL ', I4, '  CALCULATION STOPPED.')
C
          NP = N + 1
          DO 200 I = 2, NP
  200     DELRHO(I) = DMAX1 (1.0D-30, (RHO(I) - RHOC(I)))
          CALL DUBLOG (DELRHO(2), ENTC(2), N)
          DO 210 I = 2, NP
  210     ENTC(I) = ENTC(I)*GAMMAC(I)
          DO 215 I = 2, NP
  215     ENTC(I) = DEXP(ENTC(I))
          DO 220 I = 2, NP
  220     ENTC(I) = PRL(I)/ENTC(I)
          RETURN
C
C
          ENTRY USEEOS (RHO, PRE, LAMEOS, DLAMDP, N)
C         ----------
C
C     USEEOS TAKES THE SET OF CELL PRESSURES (PRE)  AND CALCULATES THE
C     CELL DENSITIES EXPECTED FOR THAT PRESSURE BASED ON THE EQUATION
C     OF STATE CONSTANTS FOR THE CELL STORED IN COMMON BLOCK /ADICOM/.
C     THE EXPECTED CELL VOLUME (LAMEOS) IS COMPUTED FOR EACH CELL AS IS
C     THE JACOBEAN DERIVATIVE DLAMDP.
C
C     RHO(I)        = DENSITY OF MATERIAL IN CELL I (I = 2, N+1) (GM/CC)
C                     THESE QUANTITIES ARE COMPUTED AS OUTPUTS OF USEEOS
C     PRE(I)        = PRESSURE GIVEN IN CELL I BETWEEN INTERFACES I AND
C                     I-1.  THESE VALUES ARE INPUT TO USEEOS (ERG/CC)
C     LAMEOS(I)     = THE CELL VOLUME REQUIRED BY THE EQUATION OF STATE
C                     GIVEN THE CELL PRESSURE PRE(I) AND E.O.S. CONSTANTS
C     DLAMDP(I)     = RATE OF CHANGE OF CELL VOLUME WITH PRESSURE IN THE
C                     EQUATION OF STATE
C     N             = NUMBER OF INTERIOR CELLS IN THE SYSTEM
C
```

```
125               REAL*8   LAMBDS(NPT),              DLAMDP(NPT)
126     C
127     C
128     C      CHECK THE INPUT TO USEEDS FOR REASONABLENESS.
129                NPTS = NPT
130                IF (N.LE.2 .OR. N.GT.NPT-2) WRITE (6, 1008) N, NPTS
131                IF (N.LE.2 .OR. N.GT.NPT-2) STOP
132                CALL MAXMIN (PRE(2), N, DRMAX, IMAX, DRMIN, IMIN)
133                IF (DRMIN .LE. 0.0D0) WRITE (6, 1009) DRMIN, IMIN
134                IF (DRMIN .LE. 0.0D0) STOP
135      1008      FORMAT ('0USEEDS INPUT PROBLEM. N OUT OF RANGE. ',  I4, I4,
136         1           ' CALCULATION STOPPED.')
137      1009      FORMAT ('0USEEDS INPUT PROBLEM. CELL PRESSURE NEGATIVE ',
138         1           1PD12.4, ' AT CELL ', I4, '  CALCULATION STOPPED.')
139     C
140                N1 = N + 1
141                DO 300 I = 2, N1
142        300     DELV(I) = DMAX1(PRE(I),0.0D0)/ENTC(I)
143                CALL DUBLOG (DELV(2), DELP(2), N)
144                DO 320 I = 2, N1
145        320     DELP(I) = DELP(I)/GAMMAC(I)
146                DO 340 I = 2, N1
147        340     DELR(I) = DEXP(DELP(I))
148     C
149     C      EVALUATE THE EQUATION OF STATE  RHO = RHOC + (PRE/ENTC)**1/GAMMAC
150                DO 360 I = 2, N1
151                RHO(I) = RHOC(I) + DELR(I)
152        360     LAMBDS(I) = MASSC(I)/RHO(I)
153                DO 380 I = 2, N1
154        380     DLAMDP(I) = - LAMBDS(I)*DELR(I)/(RHO(I)*PRE(I)*GAMMAC(I))
155                RETURN
156             END
```

Appendix B
TEST PROGRAM FOR ADINC AND UTILITIES

```
      C     ADINC - SIMPLIFIED FIVE LAYER TEST PROGRAM          MARCH 1979
      C
      C     ADIABATIC THROUGH INCOMPRESSIBLE FLOW IN ONE DIMENSION SANS SHOCK
      C
      C         THIS PROGRAM DEMONSTRATES USE OF THE ADINC PACKAGE TO SOLVE
      C     A NUMBER OF ONE-DIMENSIONAL, LAGRANGIAN FLUID DYNAMICS PROBLEMS.
      C     A WIDE CLASS OF PROBLEMS CAN BE SET UP USING THE DATA DRIVEN IN-
      C     ITIALIZER. FLEXIBLE DIAGNOSTICS FOR EACH OF THE FLUID LAYERS ARE
      C     INCLUDED. SPECIAL ATTENTION HAS BEEN PAID TO TREATING DENSITY DIS
      C     CONTINUITIES AND ZONE SIZE DISCONTINUITIES ACCURATELY. THE PRESEN
      C     VERSION OF ADINC AND ITS TEST PROGRAM ARE WRITTEN ENTIRELY IN 64
      C     BIT (DOUBLE PRECISION) FLOATING POINT ARITHMETIC. THUS CONVERGENC
      C     TO BETTER THAN 1 PART IN 10**7 IS POSSIBLE FOR PROBLEMS WITH NEAR
      C     INCOMPRESSIBILITY AND/OR EXTREME DENSITY DISCONTINUITIES WHICH
      C     REQUIRE THIS ACCURACY. FOR SOMEWHAT LESS EXTREME FLUID SYSTEMS,
      C     32 BIT FLOATING POINT COMPUTATIONS SHOULD BE ADEQUATE AND THE
      C     CORRESPONDING SINGLE PRECISION TRIDIAGONAL SOLVERS ARE AVAILABLE.
      C
      C         ADINC HAS BEEN CONSTRUCTED AS A UTILITY PACKAGE TO ADVANCE TH
      C     FOUR HYDRODYNAMIC VARIABLES..
      C
      C     RAD(I)        = POSITION (RADIUS) OF THE I-TH CELL INTERFACE (CM)
      C     VEL(I)        = VELOCITY OF THE I-TH CELL INTERFACE (CM/SEC)
      C     RHO(I)        = DENSITY IN CELL I BETWEEN INTERFACES I,I+1 (GM/CC)
      C     PRE(I)        = PRESSURE IN THE I-TH COMPUTATIONAL CELL (ERG/CC)
      C
      C     LAGRANGIAN FLUID DYNAMICS EQUATIONS ARE SOLVED INCLUDING A FLEX-
      C     IBLE EQUATION OF STATE WHICH CAN VARY FROM CELL TO CELL IN THE
      C     DISCRETIZED REPRESENTATION OF THE FLUID. ADINC HAS BEEN CAST INTO
      C     A FORM RESEMBLING THAT OF AN ORDINARY DIFFERENTIAL EQUATIONS
      C     PACKAGE. THE USER CAN REQUEST INTEGRATION TO A CERTAIN TIME INDE-
      C     PENDANT OF THE NUMBER OF CYCLES REQUIRED IN ADINC. THE USER ALSO
      C     HAS CONTROL OF VARIOUS ERROR AND INTEGRATION PARAMETERS WITHOUT
      C     HAVING TO PLUNGE INTO THE BOWELS OF THE SOLUTION METHOD ITSELF.
      C     THE EQUATIONS SOLVED ARE ..
      C
      C         D(RAD)                    D(VEL)       - 1
      C         ------  =  VEL,           ------  =  ------ GRAD (PRE),
      C           DT                        DT         RHO
      C
      C     AND THE EQUATION OF STATE ..
      C
      C                                ( PRE ) ** 1/GAMMAC
      C         RHO  =  RHOC  +        (-----)
      C                                ( ENTC).
      C
      C         THE TEST PROGRAM IS ARRANGED TO HANDLE UP TO FIVE DISTINCT
      C     LAYERS OF FLUID COMPOSED OF UP TO 200 INDIVIDUAL FINITE DIFFERENC
      C     CELLS. EACH CELL IS LAGRANGIAN AND HAS SEVERAL QUANTITIES THAT AR
      C     CONSERVED MOVING WITH THE FLUID AS LONG AS DIFFUSIVE AND OTHER
```

```
C     NON-IDEAL AND EXTERNAL SOURCE EFFECTS ARE IGNORED. THESE CONSTANTS
C     ARE COMMUNICATED THROUGHOUT THE ADINC PACKAGE IN COMMON BLOCK
C     /ADICOM/. THESE "CONSTANTS" VARY FROM CELL TO CELL ACCORDING TO
C     THE INITIAL CONDITIONS. FOLLOWING ARE THE DEFINITIONS OF THESE
C     QUANTITIES..
C
C     MATERC(I)     = CELL IDENTIFIER = L.MM WHERE 0 < L < 10 IS THE
C                                       LAYER NUMBER AND 0 < MM < 100 IS
C                                       THE MATERIAL IDENTIFIER.
C     MASSC(I)      = CELL MASS = RHO(I)*LAM(I) - HELD CONSTANT IN ADINC
C     GAMMAC(I)     = CELL ADIABATIC GAS CONSTANT - HELD FIXED IN ADINC
C     ENTC(I)       = CELL ENTROPY - CONSTANT DURING ADINC HYDRODYNAMICS
C     RHOC(I)       = DENSITY CONSTANT IN THE EQUATION OF STATE
C     NCELLS        = NUMBER OF CELLS OF FLUID IN THE CALCULATION
C
C         VARIABLE GAMMA AND ENTROPY ARE USED IN EACH LAGRANGIAN CELL
C     AND AN IMPLICIT PRESSURE ITERATION ENSURES LINEAR STABILITY, IF
C     NOT ACCURACY, FOR TIMESTEPS LONGER THAN THE COURANT CONDITION. THE
C     NONLINEAR TERMS ARE ITERATED WITH A QUADRATICALLY CONVERGENT ALGO-
C     RITHM. ADINC IS DESCRIBED IN DEL MEMORANDUM REPORT #     ,
C     1979. THE TRIDIAGONAL SOLVERS USED ARE DOCUMENTED IN NRL MEMORAN-
C     DUM REPORT #3408, NOVEMBER 1976.
C
C         PROBLEMS IN ONE OF FOUR GEOMETRIES CAN BE SET UP FOR ADINC BY
C     CHANGING THE INTEGER ALPHA IN THE CALL TO SETGEO. ALL NON-IDEAL
C     EFFECTS HAVE TO BE TREATED SEPARATELY EITHER BY IMBEDDING OR BY
C     TIMESTEP SPLITTING.
C
C     ALPHA         = 1     CARTESIAN COORDINATES.
C     ALPHA         = 2     CYLINDRICAL COORDINATES.
C     ALPHA         = 3     SPHERICAL COORDINATES.
C     ALPHA         = 4     POWER SERIES (NOZZLE) COORDINATES.
C
C         THE BOUNDARY CONDITIONS TREATED BY ADINC ARE QUITE GENERAL.
C     THE POSITIONS AND VELOCITIES OF THE REGION BOUNDING INTERFACES
C     RAD(1) AND RAD(N+1) CAN BE EXTERNALLY DETERMINED FUNCTIONS OF TIME
C     AND OTHER PHYSICAL VARIABLES DURING THE CALCULATION. THE BOUNDARY
C     CONDITIONS ARE COMMUNICATED TO THE ADINC PACKAGE VIA THE FOUR
C     ARGUMENTS...
C
C     RRNEW         = RIGHT BOUNDARY POSITION RAD(N+1) AT END OF TIMESTEP
C     RLNEW         = LEFT BOUNDARY POSITION RAD(1) AT END OF TIMESTEP
C     VRNEW         = RIGHT BOUNDARY VELOCITY VEL(N+1) AT END OF TIMESTEP
C     VLNEW         = LEFT BOUNDARY VELOCITY VEL(1) AT END OF TIMESTEP
C
C         SEVERAL AUXILIARY VARIABLES ARE USED BY ADINC AND THE CONTROL-
C     LING TEST PROGRAM WHICH SHOULD ALSO BE EXPLAINED TO THE USER.
C
C     N = NCELLS    = NUMBER OF FLUID CELLS IN THE ADINC INTEGRATION
C     DELTAT        = TIME INTERVAL FOR THE ADINC INTEGRATION WHICH MAY
C                     SUBCYCLE UP TO 100 TIMES INTERNALLY IF NEEDED FOR
C                     ACCURACY OR STABILITY.
C     ISTEP         = TIMESTEP NUMBER USED BY ADINC FOR IDENTIFICATION
C     EPSR0         = EXPLICITNESS PARAMETER FOR THE POSITION INTEGRATION
C     EPSV0         = EXPLICITNESS PARAMETER FOR THE VELOCITY INTEGRATION
C     MDAMP         = NUMBER OF CYCLES AT THE BEGINNING OF A CALCULATION
C                     IN WHICH ADDITIONAL DAMPING/SMOOTHING IS APPLIED.
C     EPSR          = EXPLICITNESS PARAMETER FOR RAD LAST USED BY ADINC
C     EPSV          = EXPLICITNESS PARAMETER FOR VEL LAST USED BY ADINC
C     GEOMCO(1..5)  = ARRAY OF FIVE COORDINATE COEFFICIENTS FOR ALPHA = 4
C     AREA(I)       = AREA OF THE I-TH CELL INTERFACE
C     RADC(I)       = POSITION OF THE I-TH CELL CENTER
```

```
C      LAMC(I)       = VOLUME OF THE I-TH FINITE DIFFERENCE CELL
C      EKINE(I)      = KINETIC ENERGY DENSITY IN THE I-TH CELL
C      ETHRM(I)      = THERMAL ENERGY DENSITY IN THE I-TH CELL
C
C
           PARAMETER  NPT = 202
           INTEGER    ALPHA
           LOGICAL    LTPRT,       LCHEM,       LTCND,       LDIFF
           LOGICAL    LZONE
           REAL*8     LAMP(NPT),   DABSV(NPT),  ETOTL(NPT),  THFRAC(NPT)
           REAL*8     ETHRM(NPT),  EKINE(NPT),  EPSR,        EPSV
           REAL*8     DTMAX,       DTMIN,       DELTAT,      TIME
           REAL*8     RLNEW,       VLNEW,       RRNEW,       VRNEW
           REAL*8     EPSR0,       EPSV0,       DTIME,       TIMED(11)
           REAL*8     DARG,        DTPRE,       DTVAL,       GEOMCO(5)
           REAL*8     RAD(NPT),    VEL(NPT),    RHO(NPT),    PRE(NPT)
           REAL*8     AREA(NPT),   RADC(NPT),   LAMC(NPT)
           REAL*8     POLD(NPT),   VOLD(NPT),   PAVG(NPT),   VAVG(NPT)
C
C      THE FOLLOWING DECLARATIONS APPEAR IN ADINC AND THE E.O.S. ROUTINES
C      FOR THE COMMON BLOCK ADICOM WHICH CONVEYS AND STORES E.O.S. INFOR-
C      MATION. IT IS NEEDED IN THE MAIN PROGRAM FOR DIAGNOSTIC REASONS.
           REAL*8     MASSC(NPT), ENTC(NPT),   RHOC(NPT),   MATERC(NPT)
           REAL*8     GAMMAC(NPT)
           COMMON     /ADICOM/  MATERC, MASSC, GAMMAC, ENTC, RHOC, NCELLS
C
           DATA       MAXSTP, IPRINT, IPLOT, ALPHA /26, 1, 0, 1/
           DATA       DTMIN, DTMAX, N /1.0D-1, 1.0D-1, 10/
           DATA       EPSR0, EPSV0 /0.50D0, 0.50D0/, TIMED /11*0.0D0/
           DATA       GEOMCO /1.0D0, 0.0D0, 0.0D0, 0.0D0, 0.0D0/
           DATA       LZONE /.FALSE./, LCHEM /.FALSE./, LDIFF /.FALSE./
           DATA       LTCND /.FALSE./, LTPRT /.TRUE./, MDAMP /1/
C
           NAMELIST /CONTRL/  MAXSTP, IPRINT, ALPHA, DTMIN, DTMAX, N,
     1                        EPSR0, EPSV0, GEOMCO, LZONE, LCHEM,
     2                        LDIFF, LTCND, LTPRT, MDAMP
C
 1000      FORMAT ('1  AFTER STEP NO. ',I5,'  DT = ', D16.8,
     1     '  THE TIME IS ', D16.8, /)
 1001      FORMAT (2X, I3, 1P9D12.4, 0P2F8.4)
 1002      FORMAT ('     I   POSITION     VELOCITY     DENSITY  ',
     1         '  PRESSURE      ENERGY     AVG PRESS   AVG VELOC ',
     2         ' CELL VOLUME     ENTROPY    THFRAC   GAMMA  ', /)
 1003      FORMAT ('0NAMELIST /CONTRL/  DEFAULTS ...')
 1004      FORMAT ('0NAMELIST /CONTRL/  UPDATES  ...')
 1005      FORMAT (' AT STEP ', I5, '   THE REQUIRED TIMESTEP ', 1PD12.4,
     1         '   BECAME SMALLER THAN THE MINIMUM STEP ', D12.4)
 2001      FORMAT ('0TIMINGS AT CYCLE ', I5, '    TIME = ', 1PD12.4, /,
     1         '       REZONE      TIMESTEP    CELL PRINT  LAYER PRNT ',
     2         '  GRAPHICS     CHEMISTRY    DIFFUSION  CONDUCTION ',
     3         '   ADINC   ')
 2002      FORMAT (2X, 1P10D12.4)
 2003      FORMAT (' TOO MANY REZONES AT CYCLE ', I4, '   NX = ', I4)
C
C
C      * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
C      CONTROL PARAMETERS ARE INITIALIZED. CHANGE FOR DIFFERENT CASES.
C      * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
           CALL COMMON
           TIME = 0.0D0
           WRITE (6, 1003)
           WRITE (6, CONTRL)
```

```
175              READ (5, CONTRL)
176              WRITE (6, 1004)
177              WRITE (6, CONTRL)
178              DTPRE = DSQRT (DTMIN*DTMAX)
179    C
180    C       * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
181    C       INITIALIZE THE PHYSICAL DATA FOR THE CALCULATION INCLUDING THE
182    C       GRID, MATERIAL, AND FLUID PROPERTIES. A USER MAY WISH TO DEVELOPE
183    C       HIS OWN PROBLEM INITIALIZER.
184    C       * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
185              CALL INITAL (MATERC, GAMMAC, RHOC, RAD, VEL, RHO, PRE, N)
186              NP = N + 1
187              RLNEW = RAD(1)
188              VLNEW = VEL(1)
189              RRNEW = RAD(NP)
190              VRNEW =  VEL(NP)
191    C
192    C       * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
193    C       INITIALIZE THE ADINC GEOMETRY AND EQUATION-OF-STATE MODULES AND
194    C       THE VARIABLE EXPLICITNESS PARAMETERS WITHIN ADINC. WHEN MATERC,
195    C       MASSC, GAMMAC, AND RHOC ARE DEFINED IN PLACE AS THEY ARE HERE, THE
196    C       CALL TO SETMAT BELOW IS, STRICTLY SPEAKING, SUPERFLUOUS.
197    C       * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
198              CALL SETGEO (ALPHA, GEOMC0)
199              CALL USEGEO (RAD, AREA, FADC, LAMC, N)
200              DO 10 I = 2, NP
201              VOLD(I) = VEL(I)
202        10    MASSC(I) = RHO(I)*LAMC(I)
203              VOLD(1) = VEL(1)
204              CALL SETMAT (MATERC, MASSC, GAMMAC, RHOC, N)
205              CALL SETEOS (RHO, PRE, N)
206              CALL SETEPS (EPSR0, EPSV0, MDAMP, EPSR, EPSV)
207    C
208    C       * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
209    C       THE LOOP OVER TIMESTEPS. THE VARIOUS SUBSECTIONS ARE TIMED FOR
210    C       DIAGNOSTIC PURPOSES.
211    C       * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
212              DO 9999 ISTEP = 1, MAXSTP
213    C
214    C       WARNING ... THE FOLLOWING BLOCK OF CODE CONTROLS THE PRINTOUT
215    C       INTERVAL AND THE EXPLICITNESS PARAMETERS NEAR TURNAROUND IN THE
216    C       LINUS SIMULATION. THEY ARE PROBLEM SPECIFIC AND SHOULD BE REMOVED
217    C       OR BYPASSED FOR GENERAL APPLICATIONS.
218              IF (ISTEP.GE.665 .AND. ISTEP.LE.710)
219             1     CALL SETEPS (0.0D0, 0.0D0, MDAMP, EPSR, EPSV)
220              IF (ISTEP.EQ.650) IPRINT = 5
221              IF (ISTEP.EQ.665) IPRINT = 1
222              IF (ISTEP.EQ.675) IPRINT = 5
223              IF (ISTEP.EQ.710) IPRINT = 50
224    C
225    C       * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
226    C       LAGRANGIAN REZONE FACILITY ** TO BE DEVELOPED
227    C       * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
228              IF (.NOT. LZONE) GO TO 15
229              CALL SECOND (1, DTIME)
230    C         * * * *
231    C         * * * *
232              CALL SECOND (0, DTIME)
233              TIMED( 1) = TIMED( 1) + DTIME
234        15    CONTINUE
235    C
```

```
C     * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
C     CALCULATE THE TIMESTEP BASED ON FLOW VELOCITY AND EXTERNAL LIMITS.
C     * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
          CALL SECOND (1, DTIME)
          DO 20 I = 1, NP
          DABSV(I) = DABS(VEL(I))
   20     DABSV(I) = DMAX1 (DABSV(I), DABS(VOLD(I)))
          CALL DTFLOW (RAD, DABSV, DTVAL, N)
          DELTAT = DMIN1 (DTMAX, 0.35D0*DTVAL)
          DELTAT = DMIN1 (DELTAT, 1.1D0*DTPRE)
          IF (DELTAT .LT. DTMIN) WRITE (6, 1005) ISTEP, DELTAT, DTMIN
          DELTAT = DMAX1 (DELTAT, DTMIN)
          DTPRE = DELTAT
          CALL SECOND (0, DTIME)
          TIMED( 2) = TIMED( 2) + DTIME
C
C     * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
C     THE RESULTS AND DIAGNOSTICS ARE PRINTED BY CELL AND BY LAYER. THE
C     UTILITY ERGPRT USES THE CELL IDENTIFIER MATERC(I) TO DISTINGUISH
C     LAYER BOUNDARIES FOR CERTAIN IMPORTANT CONSERVATION SUMS.
C     * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
          IF (IPRINT .EQ. 0) GO TO 30
          IF (MOD(ISTEP-1,IPRINT) .NE. 0) GO TO 30
C
C     * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
C     CALCULATE THE ENERGIES AND OTHER QUANTITIES AS DIAGNOSTICS.
C     * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
          CALL SECOND (1, DTIME)
          CALL USEGEO (RAD, AREA, RADC, LAMC, N)
          DO 25 I = 2, NP
          ETHRM(I) = PRE(I) /(GAMMAC(I) - 1.0D0)
C
C     THE FOLLOWING FUNCTION EVALUATES THE ENERGY INTEGRAL FOR A GAMMA
C     EQUALS 1/2 "SOLID" EQUATION OF STATE.
          IF (RHOC(I) .NE. 0.0D0)
     1        DARG = DMAX1 (RHO(I)/RHOC(I), 1.000000000001D0)
          IF (GAMMAC(I) .EQ. 0.5D0) ETHRM(I) = -PRE(I)*(1.0D0
     1      - DARG*DATAN (DSQRT(DARG - 1.0D0))/DSQRT(DARG - 1.0D0))
C
          LAMP(I) = (RAD(I) - RADC(I))*(LAMC(I) + 0.5D0*(RADC(I) -
     1        RAD(I-1))*(AREA(I) - AREA(I-1)))/(RAD(I) - RAD(I-1))
          EKINE(I) = 0.5D0*RHO(I)*(VEL(I)**2*LAMP(I) + VEL(I-1)**2*
     1        (LAMC(I) - LAMP(I)))/LAMC(I)
          ETOTL(I) = EKINE(I) + ETHRM(I)
   25     THFRAC(I) = ETHRM(I)/ETOTL(I)
          JSTEP = ISTEP - 1
          WRITE (6, 1000) JSTEP, DELTAT, TIME
          WRITE (6, 1002)
          WRITE (6, 1001) (I, RAD(I), VEL(I), RHO(I), PRE(I), ETOTL(I),
     1        PAVG(I), VAVG(I), LAMC(I), ENTC(I), THFRAC(I), GAMMAC(I),
     2        I = 1, NP)
          WRITE (6, 2001) ISTEP, TIME
          WRITE (6, 2002) (TIMED (JJ), JJ = 1, 9)
C
C     * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
C     CHECK ON THE INTEGRATOR PERFORMANCE VIA ADINCO. THE ARGUMENT 1
C     PREVENTS THE RESET OF THE NCALL POINTER IN ADINC TO ZERO. THUS
C     SMOOTHING IS ONLY ENABLED ON THE INITIAL DATA.
C     * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
          CALL ADINCO (1, ISTEP)
          WRITE (6, 1001)
          CALL SECOND (0, DTIME)
```

```
298                 TIMED( 3) = TIMED( 3) + DTIME
299     C
300     C       * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
301     C       ENERGY AND OTHER DIAGNOSTICS SHELL BY SHELL. THE MATERIAL CAN VARY
302     C       WITHIN A SHELL BUT THE SHELLS MUST BE ENCOUNTERED IN NUMERICAL
303     C       SEQUENCE FROM 1 TO AT MOST 5.
304     C       * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
305                 CALL SECOND (1, DTIME)
306                 CALL ERGPRT (RAD, VEL, AREA, LAMC, RHO, PRE, N, EKINE, ETHRM)
307                 CALL SECOND (0, DTIME)
308                 TIMED( 4) = TIMED( 4) + DTIME
309     C
310         30      CONTINUE
311     C
312     C       * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
313     C       PERFORM GRAPHICS ** TO BE DEVELOPED
314     C       * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
315                 IF (IPLOT .EQ. 0) GO TO 35
316                 IF (MOD(ISTEP-1, IPLOT) .NE. 0) GO TO 35
317                 CALL SECOND (1, DTIME)
318     C           * * * *
319     C           * * * *
320                 CALL SECOND (0, DTIME)
321                 TIMED( 5) = TIMED( 5) + DTIME
322         35      CONTINUE
323     C
324     C       * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
325     C       INTEGRATE THE CHEMICAL KINETIC RATE EQUATIONS ** TO BE DEVELOPED
326     C       * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
327                 IF (.NOT.LCHEM ) GO TO 40
328                 CALL SECOND (1, DTIME)
329     C           * * * *
330     C           * * * *
331                 CALL SECOND (0, DTIME)
332                 TIMED( 6) = TIMED( 6) + DTIME
333         40      CONTINUE
334     C
335     C       * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
336     C       PERFORM DIFFUSION CALCULATIONS ** TO BE DEVELOPED
337     C       * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
338                 IF (.NOT.LDIFF) GO TO 50
339                 CALL SECOND (1, DTIME)
340     C           * * * *
341     C           * * * *
342                 CALL SECOND (0, DTIME)
343                 TIMED( 7) = TIMED( 7) + DTIME
344         50      CONTINUE
345     C
346     C       * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
347     C       PERFORM CONDUCTION AND ENERGY ADDITIONS ** TO BE DEVELOPED
348     C       * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
349                 IF (.NOT.LTCND) GO TO 60
350                 CALL SECOND (1, DTIME)
351     C           * * * *
352     C           * * * *
353                 CALL SECOND (0, DTIME)
354                 TIMED( 8) = TIMED( 8) + DTIME
355         60      CONTINUE
356     C
357     C       * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
358     C       CALCULATE THE AUGMENTED PRESSURE AND UPDATE THE ENTROPY IF NON-
359     C       IDEAL PHYSICS IS INCLUDED. SAVE THE OLD PRESSURE AND VELOCITY.
360     C       * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
```

```
361               DO 400 I = 2, NP
362   C           * * * *
363   C           * * * *
364     400       CONTINUE
365               IF (LCHEM .OR. LDIFF .OR. LTCND) CALL SETEOS (RHO, PRE, N)
366               DO 100 I = 2, NP
367               POLD(I) = PRE(I)
368     100       VOLD(I) = VEL(I)
369               VOLD(1) = VEL(1)
370   C
371   C       * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
372   C       INTEGRATE A HYDRODYNAMIC TIMESTEP OF LENGTH DELTAT AFTER RESETTING
373   C       THE BOUNDARY CONDITIONS TO THE END OF THE TIMESTEP.
374   C       * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
375               IF (.NOT.LTPRT) GO TO 70
376               CALL SECOND (1, DTIME)
377               VRNEW = VEL(NP)
378               RRNEW = PRNEW + DELTAT*VRNEW
379               VLNEW = VEL(1)
380               RLNEW = RLNEW + DELTAT*VLNEW
381               CALL ADINC (RAD, VEL, RHO, PRE, N, DELTAT, ISTEP,
382          1                RRNEW, RLNEW, VRNEW, VLNEW)
383               CALL SECOND (0, DTIME)
384               TIMED( 9) = TIMED( 9) + DTIME
385      70       CONTINUE
386   C
387   C       * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
388   C       CALCULATE THE AVERAGE VELOCITY AND PRESSURE ACTUALLY USED BY ADINC
389   C       TO ADVANCE THE POSITIONS (RAD) AND VELOCITIES (VEL) FOR DIAGNOSIS.
390   C       * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
391               CALL SETEPS (EPSR0, EPSV0, MDAMP, EPSR, EPSV)
392               DO 110 I = 2, NP
393               VAVG(I) = EPSR*VOLD(I) + (1.0D0 - EPSR)*VEL(I)
394     110       PAVG(I) = EPSV*POLD(I) + (1.0D0 - EPSV)*PRE(I)
395               VAVG(1) = EPSR*VOLD(1) + (1.0D0 - EPSR)*VEL(1)
396   C
397               TIME = TIME + DELTAT
398      9999     CONTINUE
399               STOP
400           END
```

```
      SUBROUTINE ERGPRT (RADN, VNEW, AREA, LAM, PNEW, PNEW,
     1          NX, RNEW, ENEW)
C
C     ERGPRT TAKES THE CELL AND INTERFACE DATA AND USES THE MATERIAL
C     IDENTIFIER ARRAY MATERC TO RETABULATE VARIOUS PHYSICAL QUANTITIES
C     BY LAYER RATHER THAN BY CELL. THE DIAGNOSTIC IS PARTICULARLY USE-
C     FUL FOR HETEROGENEOUS CALCULATIONS. ONLY FIVE LAYERS ARE PERMITTED
C     CURRENTLY BUT THIS COULD BE INCREASED EASILY BY CHANGING SOME OF
C     THE LOOP LIMITS AND FORMATS. THANKS TO ELLIOT DENT FOR DEVELOPING
C     THIS ROUTINE FOR ADINC.
C
          PARAMETER  NPT = 202
          REAL*8    RNEW(NPT),  PNEW(NPT),  KNEW(NPT),  ENEW(NPT)
          REAL*8    RADN(NPT),  VNEW(NPT),  AREA(NPT),  LAM(NPT)
          REAL*8    XRNEW(11),  XINEW(11),  XENEW(11),  XGAM(11)
          REAL*8    XMASS(11),  XRHO(11),   XPRE(11),   XVOL(11)
          REAL*8    XRAD(11),   XVEL(11),   XAREA(11),  XENT(11)
          REAL*8    TGAM,       TENT,       TRHOC,      XRHOC(11)
          REAL*8    TMASS,      TINEW,      TKNEW,      TENEW
          REAL*8    TRHO,       TPRE,       TVOL
          REAL*8    MASSC(NPT), ENTC(NPT),  RHOC(NPT),  MATERC(NPT)
          REAL*8    GAMMAC(NPT)
          COMMON    /ADICOM/  MATERC, MASSC, GAMMAC, ENTC, RHOC, NCELLS
C
 1006     FORMAT(' THERMAL ERG ', 1P6D17.8)
 1007     FORMAT(' KINETIC ERG ', 1P6D17.8)
 1008     FORMAT('  TOTAL  ERG ', 1P6D17.8)
 1009     FORMAT('0', 13X, '     TOTALS           SHELL 1          ',
     1 '  SHELL 2          SHELL 3          SHELL 4          SHELL 5 ')
 2006     FORMAT(' INTERFACE POSITION', 1P6D17.8)
 2007     FORMAT(' INTERFACE VELOCITY', 1P6D17.8)
 2008     FORMAT(' INTERFACE AREA    ', 1P6D17.8)
 2009     FORMAT( 3X, 'LAYER BOUNDARY', 7X, 'INTER 1', 10X, 'INTER 2',
     1        10X, 'INTER 3', 10X, 'INTER 4', 10X, 'INTER 5', 10X,
     2        'INTER 6')
 4006     FORMAT(' VOL AVG RHO ', 1P6D17.8)
 4007     FORMAT(' VOL AVG PRE ', 1P6D17.8)
 4008     FORMAT(' LAYER VOLUME', 1P6D17.8)
 4005     FORMAT(' LAYER MASS  ', 1P6D17.8)
 4009     FORMAT(' VOL AVG GAM ', 1P6D17.8)
 4010     FORMAT(' VOL AVG ENT ', 1P6D17.8)
 4011     FORMAT(' VOL AVG RHOC', 1P6D17.8)
 4012     FORMAT (5X, /)
C
C
C     THE VARIOUS SUMMANDS ARE INITIALIZED TO ZERO.
          NP = NX + 1
          TMASS = 0.0D0
          TINEW = 0.0D0
          TKNEW = 0.0D0
          TENEW = 0.0D0
          TRHO = 0.0D0
          TPRE = 0.0D0
          TVOL = 0.0D0
          TGAM = 0.0D0
          TENT = 0.0D0
          TRHOC = 0.0D0
          DO 50 I = 1, 10
          XMASS(I) = 0.0D0
          XINEW(I) = 0.0D0
          XKNEW(I) = 0.0D0
          XENEW(I) = 0.0D0
```

```
      XRHO(I) = 0.0D0
      XPRE(I) = 0.0D0
      XGAM(I) = 0.0D0
      XENT(I) = 0.0D0
      XRHOC(I) = 0.0D0
      XRAD(I+1) = 0.0D0
      XVEL(I+1) = 0.0D0
      XAREA(I+1) = 0.0D0
50    XVOL(I) = 0.0D0
C
C     THE VARIOUS SUMMATIONS ARE PERFORMED.
      JSHL = MATERC(2)
      XRAD(1) = RADN(1)
      XVEL(1) = VNEW(1)
      XAREA(1) = AREA(1)
      II = 1
      DO 58 I = 2, NP
      IHLD = I
      ISHL = MATERC(I)
      IF (ISHL .LT. 1) GO TO 300
      IF (ISHL .GT. 5) GO TO 301
      IF (ISHL .EQ.JSHL) GO TO 54
      JSHL = ISHL
      XRAD(II+1) = RADN(I-1)
      XVEL(II+1) = VNEW(I-1)
      XAREA(II+1) = AREA(I-1)
      XENEW(II) = XINEW(II) + XKNEW(II)
      II = II + 1
54    XKNEW(II) = XKNEW(II) + KNEW(I)*LAM(I)
      XINEW(II) = XINEW(II) + ENEW(I)*LAM(I)
      XRHO(II) = XRHO(II) + RNEW(I)*LAM(I)
      XPRE(II) = XPRE(II) + PNEW(I)*LAM(I)
      XGAM(II) = XGAM(II) + GAMMAC(I)*LAM(I)
      XENT(II) = XENT(II) + ENTC(I)*LAM(I)
      XRHOC(II) = XRHOC(II) + RHOC(I)*LAM(I)
      XVOL(II) = XVOL(II) + LAM(I)
58    XMASS(II) = XMASS(II) + RNEW(I)*LAM(I)
      XENEW(II) = XINEW(II) + XKNEW(II)
      IE = II
      XRAD(IE+1) = RADN(NP)
      XVEL(IE+1) = VNEW(NP)
      XAREA(IE+1) = AREA(NP)
      DO 60 I = 1, II
      TINEW = TINEW + XINEW(I)
      TKNEW = TKNEW + XKNEW(I)
      TENEW = TENEW + XENEW(I)
      TRHO = TRHO + XRHO(I)
      TPRE = TPRE + XPRE(I)
      TGAM = TGAM + XGAM(I)
      TENT = TENT + XENT(I)
      TRHOC = TRHOC + XRHOC(I)
      TVOL = TVOL + XVOL(I)
60    TMASS = TMASS + XMASS(I)
      TRHO = TRHO/TVOL
      TPRE = TPRE/TVOL
      TGAM = TGAM/TVOL
      TENT = TENT/TVOL
      TRHOC = TRHOL/TVOL
      DO 70 J = 1, IE
      XRHO(J) = XRHO(J)/XVOL(J)
      XPRE(J) = XPRE(J)/XVOL(J)
      XGAM(J) = XGAM(J)/XVOL(J)
```

```
125               XENT(J) = XENT(J)/XVOL(J)
126        70     XRHOC(J) = XRHOC(J)/XVOL(J)
127   C
128   C       THE LAYER-BY-LAYER CROSS TABULATIONS ARE PRINTED.
129               II = II + 1
130               WRITE(6, 2009)
131               WRITE(6, 2006)(XRAD(I), I=1, II)
132               WRITE(6, 2007)(XVEL(I), I=1, II)
133               WRITE(6, 2008)(XAREA(I), I=1, II)
134               WRITE(6, 1009)
135               WRITE(6, 1006) TINEW, (XINEW(J), J=1, IE)
136               WRITE(6, 1007) TKNEW, (XKNEW(J), J=1, IE)
137               WRITE(6, 1008) TENEW, (XENEW(J), J=1, IE)
138               WRITE(6, 4006) TRHO, (XRHO(J), J=1, IE)
139               WRITE(6, 4007) TPRE, (XPRE(J), J=1, IE)
140               WRITE (6, 4009) TGAM, (XGAM(J), J = 1, IE)
141               WRITE (6, 4010) TENT, (XENT(J), J = 1, IE)
142               WRITE (6, 4011) TRHOC, (XRHOC(J), J = 1, IE)
143               WRITE(6, 4006) TVOL, (XVOL(J), J=1, IE)
144               WRITE(6, 4005) TMASS, (XMASS(J), J=1, IE)
145               WRITE (6, 4012)
146               RETURN
147   C
148   C       PRINT A WARNING IF ANY SHELL POINTER IS LESS THAN ONE.
149         300   WRITE (6, 3001) ISHL, IHLD
150        3001   FORMAT ('0ISHL = ', I3, '  LESS THAN 1 AT CELL ', I4)
151               RETURN
152   C
153   C       PRINT A WARNING IF ANY SHELL POINTER IS GREATER THAN FIVE.
154         301   WRITE (6, 3011) ISHL, IHLD
155        3011   FORMAT ('0ISHL = ', I3, '  GREATER THAN 5 AT CELL ', I4)
156               RETURN
157               END
```

```
      SUBROUTINE INITAL (MATER, GAMMA, RHOCON, RAD, VEL, RHO, PRE, N)
C
C         INITAL SETS UP A RATHER GENERAL MULTILAYER FLUID DYNAMICS PRO-
C     BLEM.  UP TO FIVE LAYERS OF CONSTANT (BUT DIFFERENT) DENSITY, PRES-
C     SURE, AND LINEARLY VARYING VELOCITY CAN BE INITIALIZED.  EACH LAYER
C     CAN HAVE A DIFFERENT EQUATION OF STATE BUT WITHIN EACH LAYER RHO-
C     CON, GAMMA, AND THE MATERIAL MATER ARE FIXED.  A VARIABLE SPACING
C     ACROSS THE SHELL IS ALLOWED UNDER CONTROL OF THE PARAMETER POWS.
C     PROVISION IS ALSO MADE FOR A SINUSOIDAL VELOCITY PERTURBATION.
C
          PARAMETER  NPT = 202
          REAL*8    RN,          VN,          R0,          V0
          REAL*8    MATERS,      GAMMAS,      RHOS,        RHOCS
          REAL*8    PRES,        DELTAR,      DELTAV
          REAL*8    ARGI,        DRHO,        DVEL,        POWS
          REAL*8    MATER(NPT),                GAMMA(NPT), RHOCON(NPT)
          REAL*8    RAD(NPT),    VEL(NPT),    RHO(NPT),    PRE(NPT)
C
          DATA      NSHELL, RN, VN /1, 1.0D-20, 0.0D0/
          DATA      MODE, DVEL, DRHO /1, 1.0D-2, 0.0D0/
          DATA      LCELLS, MATERS, RHOCS /0, 1.01D0, 0.0D0/
C
          NAMELIST /SHLINI/ NSHELL, RN, VN, MODE, DRHO, DVEL
          NAMELIST /SHLDAT/ LCELLS, RN, VN, MATERS, GAMMAS, RHOS, POWS,
     1              PRES, RHOCS
C
 1001     FORMAT ('0NAMELIST /SHLDAT/  DATA FOR LAYER', I2)
C
C
C     INITIALIZE THE LOOP OVER LAYERS.
 1003     FORMAT ('0NAMELIST /SHLINI/  DEFAULTS ...')
          WRITE (6, 1003)
          WRITE (6, SHLINI)
          READ(5, SHLINI)
 1004     FORMAT ('0NAMELIST /SHLINI/  UPDATES  ...')
          WRITE (6, 1004)
          WRITE (6, SHLINI)
          RAD(1) = RN
          VEL(1) = VN
          I2 = 1
          DO 100 ISHELL = 1, NSHELL
          POWS = 1.0D0
          R0 = RAD(I2)
          V0 = VEL(I2)
C
C     READ IN THE DATA FOR THE SHELLS ONE AT A TIME.
          READ (5, SHLDAT)
          WRITE (6, 1001) ISHELL
          WRITE (6, SHLDAT)
          I1 = I2 + 1
          I2 = I1 + LCELLS - 1
C
C     SET THE SHELL DATA INTO THE OUTPUT ARRAYS.
          DO 200 I = I1, I2
          RHOCON(I) = RHOCS
          GAMMA(I) = GAMMAS
          MATER(I) = MATERS
          RHO(I) = RHOS
          PRE(I) = PRES
          DELTAV = DFLOAT(I - I1 + 1)/DFLOAT(I2 - I1 + 1)
          DELTAR = DELTAV**POWS
          RAD(I) = DELTAR*RN + (1.0D0 - DELTAR)*R0
```

```
63                VEL(I) = DELTAV*VN + (1.0D0 - DELTAV)*V0
64          200   CONTINUE
65          C
66          100   CONTINUE
67                N = I2 - 1
68                NP = N + 1
69          C
70          C     ADD IN A SINUSOIDAL VELOCITY PERTURBATION.
71                DO 300 I = 2, NP
72                ARGI = 3.1415926535897900*DFLOAT(MODE)*RAD(I)/RAD(NP)
73          300   VEL(I) = VEL(I) + DVEL*DSIN(ARGI)
74                RETURN
75          END
```

```
1           SUBROUTINE MAXMIN(A, N, AMAX, IMAX, AMIN, IMIN)
2     C
3     C     THE MAXIMUM (AMAX) AND MINIMUM (AMIN) OF THE N DOUBLE PRECISION
4     C     VALUES OF VECTOR A ARE DETERMINED AND THE CORRESPONDING INDICES IN
5     C     THE ARRAY (AS WELL AS THE EXTREME VALUES) ARE RETURNED. THE MAXVAL
6     C     AND MINVAL FUNCTIONS COMPILE AS INLINE VECTOR OPERATIONS BUT ARE
7     C     RATHER UNWIELDY TO USE AND DO NOT COMPILE PROPERLY UNDER THE FX
8     C     FORTRAN COMPILER.
9     C
10                PARAMETER  NPT=202
11                REAL*8     A(N),          AMAX,          AMIN
12                INTEGER    IMAX,          IMIN
13    C
14                IMAX = MAXVAL(A) + 1
15                IMIN = MINVAL(A) + 1
16                AMAX = A(IMAX)
17                AMIN = A(IMIN)
18                RETURN
19    C
20    C
21          ENTRY DUBLOG (DA, DLNA, N)
22    C
23    C     THE (VECTORIZED) DOUBLE PRECISION LOGARITHMS OF THE N INPUT VALUES
24    C     IN REAL*8 ARRAY DA ARE COMPUTED AND RETURNED IN THE ARRAY DLNA.
25    C     AS OF SUMMER 1978, THE ASC, FOR SOME OBSCURE REASON, DID NOT HAVE
26    C     A DOUBLE PRECISION VECTORIZED LOGARITHM. THIS ROUTINE FILLS THAT
27    C     PURPOSE.
28    C
29                REAL*8     DA(N), DLNA(N), SCR(NPT), DL(NPT)
30                REAL       SA(NPT), SLNA(NPT)
31    C
32                DO 10 I = 1, N
33                SA(I) = DA(I)
34          10    SLNA(I) = ALOG(SA(I))
35    C
36                DO 20 I = 1, N
37                DLNA(I) = SLNA(I)
38          20    SCR(I) = DEXP (DLNA(I))
39    C
40                DO 30 I = 1, N
41                SCR(I) = DA(I)/SCR(I) - 1.0D0
42                DL(I) = SCR(I)*(1.0D0 - SCR(I)*(0.5D0 - 0.16666666D0*SCR(I)))
43          30    DLNA(I) = DLNA(I) + DL(I)
44                RETURN
45          END
```

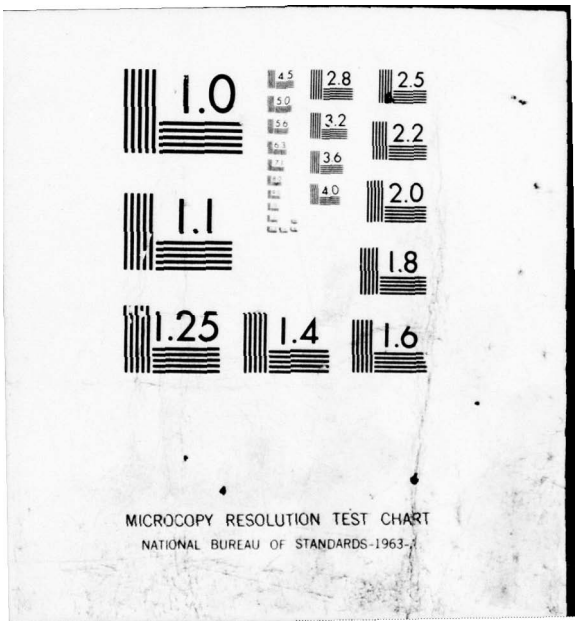
Appendix C
STANDARD TEST #1

```
1                  AN ADIABATIC SOUND WAVE TEST
2
3     &CONTRL
4     &END
5     &SHLINI
6     &END
7     &SHLDAT
8          LCELLS=10, RN=1.0D0, GAMMAS=1.4D0, RHOS=1.4D0, PRES=1.0D0,
9          POWS=1.0D0,
10    &END
11
12
13              THE TIMINGS FOR ADINC, EVEN THOUGH IT IS VECTORIED, ARE A LOT
14         SLOWER THAN CORRESPONDING EXPLICIT AND EULERIAN CALCULATIONS. THE
15         ADINC PACKAGE IS CONSTRUCTED FOR FLEXIBILITY AND ACCURACY, NOT
16         RAW SPEED.  SEVERAL CALCULATIONS USING STANDARD TEST #1 HAVE BEEN
17         PERFORMED TO CONSTRUCT THE FOLLOWING TIMING TABLE. NOTE: MOST OF
18         THE COMPUTING IN ADINC OCCURS IN THE TRANSCENDENTAL FUNCTION
19         EVALUATIONS FOR THE EQUATION OF STATE.
20
21              NCELLS   CPU TIME PER CALL   CPU TIME PER ITERATION
22              ------   ----------------   ----------------------
23
24               10          0.0082 SEC            0.0023 SEC
25
26               15          0.0099 SEC            0.0026 SEC
27
28               30          0.0132 SEC            0.0036 SEC
29
30               50          0.0175 SEC            0.0046 SEC
31
32              100          0.0276 SEC            0.0073 SEC
33
34              200          0.0475 SEC            0.0119 SEC
```

AD-A070 361 NAVAL RESEARCH LAB WASHINGTON DC F/G 20/4
ADINC: AN IMPLICIT LAGRANGIAN HYDRODYNAMICS CODE.(U)
JUN 79 J P BORIS
UNCLASSIFIED NRL-MR-4022 NL

2 OF 2
AD A070861

END
DATE FILMED
7-79
DDC


1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0
4.5
5.0
5.6
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

```
NAMELIST /CONTRL/  DEFAULTS ...
&CONTRL
MAXSTP=          20,IPRINT=          1,ALPHA =          1,DTMIN =     0.1000000000000000,DTMAX =     0.1000000000000000,N     =
        10,EPSRO =     0.5000000000000000,EPSVO =     0.5000000000000000,
GEOMCO=      1.0000000000000000,     0.0000000000000000,     0.0000000000000000,     0.0000000000000000,     0.0000000000000000,
LZONE =          F,LCHEM =          F,LLIFF =          F,LTEMP =          F,LTERT =          T,NDAMP =          1,
&END

NAMELIST /CONTRL/  UPDATES ...
&CONTRL
MAXSTP=          20,IPRINT=          1,ALPHA =          1,DTMIN =     0.1000000000000000,DTMAX =     0.1000000000000000,N     =
        10,EPSRO =     0.5000000000000000,EPSVO =     0.5000000000000000,
GEOMCO=      1.0000000000000000,     0.0000000000000000,     0.0000000000000000,     0.0000000000000000,     0.0000000000000000,
LZONE =          F,LCHEM =          F,LLIFF =          F,LTEMP =          F,LTERT =          T,NDAMP =          1,
&END

NAMELIST /SHLINI/  DEFAULTS ...
&SHLINI
NSHELL=          1,RN    = 0.1000000000000000D-19,VN    =     0.0000000000000000,NODE  =          1,DRHO  =     0.0000000000000000,
DVEL  = 0.1000000000000000D-01,
&END

NAMELIST /SHLINI/  UPDATES ...
&SHLINI
NSHELL=          1,RN    = 0.1000000000000000D-19,VN    =     0.0000000000000000,NODE  =          1,DRHO  =     0.0000000000000000,
DVEL  = 0.1000000000000000D-01,
&END

NAMELIST /SHLDAT/  DATA FOR LAYER 1
&SHLDAT
LCELLS=          16,RN    =     1.0000000000000000,VN    =     0.0000000000000000,WATERS=     1.0100000000000000,GAMMAS=
     1.4000000000000000,RHOS  =     1.4000000000000000,FORS  =     1.0000000000000000,PRES  =     1.0000000000000000,RHOCS =
     0.6000000000000000,
&END
```

AFTER STEP NO. 0 DT = 0.10000000D 00 THE TIME IS 0.00000000D 00

I	POSITION	VELOCITY	DENSITY	PRESSURE	ENERGY	AVG PRESS	AVG VELOC	CELL VOLUME	ENTROPY	THERMAL	GAMMA
1	1.0000D-20	0.0000D 00	2.1399D 68	2.1399D 68	2.1399D 68	2.1399D 68	2.1399D 68	2.1399D 68	2.1399D 68	**********	
2	1.0000D-01	3.0902D-03	1.4000D 00	1.0000D 00	2.5000D 00	2.1399D 68	2.1399D 68	1.0000D-01	6.2434D-01	1.0000	1.4000
3	2.0000D-01	5.8779D-03	1.4000D 00	1.0000D 00	2.5000D 00	2.1399D 68	2.1399D 68	1.0000D-01	6.2434D-01	1.0000	1.4000
4	3.0000D-01	8.0902D-03	1.4000D 00	1.0000D 00	2.5000D 00	2.1399D 68	2.1399D 68	1.0000D-01	6.2434D-01	1.0000	1.4000
5	4.0000D-01	9.5106D-03	1.4000D 00	1.0000D 00	2.5001D 00	2.1399D 68	2.1399D 68	1.0000D-01	6.2434D-01	1.0000	1.4000
6	5.0000D-01	1.0000D-02	1.4000D 00	1.0000D 00	2.5001D 00	2.1399D 68	2.1399D 68	1.0000D-01	6.2434D-01	1.0000	1.4000
7	6.0000D-01	9.5106D-03	1.4000D 00	1.0000D 00	2.5001D 00	2.1399D 68	2.1399D 68	1.0000D-01	6.2434D-01	1.0000	1.4000
8	7.0000D-01	8.0902D-03	1.4000D 00	1.0000D 00	2.5001D 00	2.1399D 68	2.1399D 68	1.0000D-01	6.2434D-01	1.0000	1.4000
9	8.0000D-01	5.8779D-03	1.4000D 00	1.0000D 00	2.5000D 00	2.1399D 68	2.1399D 68	1.0000D-01	6.2434D-01	1.0000	1.4000
10	9.0000D-01	3.0902D-03	1.4000D 00	1.0000D 00	2.5000D 00	2.1399D 68	2.1399D 68	1.0000D-01	6.2434D-01	1.0000	1.4000
11	1.0000D 00	3.3135D-17	1.4000D 00	1.0000D 00	2.5000D 00	2.1399D 68	2.1399D 68	1.0000D-01	6.2434D-01	1.0000	1.4000

TIMINGS AT CYCLE 1 TIME = 0.00000 00

REZONE	TIMESTEP	CELL PRINT	LAYER PRNT	GRAPHICS	CHEMISTRY	DIFFUSION	CONDUCTION	ADINC
0.0000 00	2.9752D-04	0.0000 00	0.0000 00	0.0000 00	0.0000 00	0.0000 00	0.0000 00	0.0000 00

ADINC FREQUENCY COUNTERS (SINCE LAST CHECK) AT CYCLE 1
NO. CALLS = 0 NO. TIMESTEPS = 0 TOTAL NO. ITERATIONS = 0

LAYER BOUNDARY	INTER 1	INTER 2	INTER 3	INTER 4	INTER 5	INTER 6
INTERFACE POSITION	1.0000000L-20	1.0000000D 00				
INTERFACE VELOCITY	0.0000000L 00	3.3134750D-17				
INTERFACE AREA	1.0000000L 00	1.0000000D 00				

	TOTALS	SHELL 1	SHELL 2	SHELL 3	SHELL 4	SHELL 5
THERMAL ERG	2.5000000D 00	2.5000000D 00				
KINETIC ERG	3.5000000L-05	3.5000000D-05				
TOTAL ERG	2.5000350L 00	2.5000350D 00				
VOL AVG RHO	1.4000000L 00	1.4000000D 00				
VOL AVG PRE	1.0000000L 00	1.0000000D 00				
VOL AVG GAM	1.4000000L 00	1.4000000D 00				
VOL AVG ENT	6.24339411D-01	6.24339411D-01				
VOL AVG RHOC	0.0000000L 00	0.0000000D 00				
LAYER VOLUME	1.0000000L 00	1.0000000D 00				
LAYER MASS	1.4000000L 00	1.4000000D 00				

AFTER STEP NO. 5 DT = 0.10[illegible] AND THE TIME IS 0.500000[illegible]

I	POSITION	VELOCITY	DENSITY	PRESSURE	ENERGY	AVG PRESS	AVG VELOC	CELL VOLUME	ENTROPY	THERMAC	GAMMA
1	1.0000D-20	0.0000D 00	2.1399[illegible] 00	2.1399[illegible] 00	2.1399[illegible] 00	2.1399D 00	0.0000 00	2.1399D 00	2.1399[illegible] 00	**********	**********
2	1.0099D-01	8.5092D-05	1.3066[illegible] 00	9.8627[illegible]-01	2.4057[illegible] 00	9.8665D-01	5.5260D-04	1.0099D-01	6.2434D-01	1.0000	1.4000
3	2.0189D-01	1.5431D-04	1.3076[illegible] 00	9.8762D-01	2.4090[illegible] 00	9.8795D-01	1.0044D-03	1.0089D-01	6.2434D-01	1.0000	1.4000
4	3.0279D-01	1.9624D-04	1.3090[illegible] 00	9.9019D-01	2.4755D 00	9.9145D-01	1.4231D-03	1.0071D-01	6.2434[illegible]-01	1.0000	1.4000
5	4.0304D-01	2.0686D-04	1.3937[illegible] 00	9.9372[illegible]-01	2.4843D 00	9.9388D-01	1.6518[illegible]-03	1.0045D-01	6.2434[illegible]-01	1.0000	1.4000
6	5.0320D-01	1.4982D-04	1.3979[illegible] 00	9.9768[illegible]-01	2.4907D 00	9.9793D-01	1.7121[illegible]-03	1.0015D-01	6.2434D-01	1.0000	1.4000
7	6.0330D-01	1.5432[illegible]-04	1.4023[illegible] 00	1.0023[illegible] 00	2.5057D 00	1.0022D 00	1.6040[illegible]-03	9.9839D-02	6.2434[illegible]-01	1.0000	1.4000
8	7.0258D-01	1.1123D-04	1.4064[illegible] 00	1.0064D 00	2.5161[illegible] 00	1.0163D 00	1.3472D-03	9.9543D-02	6.2434D-01	1.0000	1.4000
9	8.0187D-01	6.9[illegible]960-05	1.4100[illegible] 00	1.0100D 00	2.5250D 00	1.0097D 00	9.6850D-04	9.9293D-02	6.2434D-01	1.0000	1.4000
10	9.0098D-01	3.2555D-05	1.4125[illegible] 00	1.0120[illegible] 00	2.5314D 00	1.0122D 00	5.0569[illegible]-04	9.9112D-02	6.2434[illegible]-01	1.0000	1.4000
11	1.0000D 00	3.3135D-17	1.4139[illegible] 00	1.0139[illegible] 00	2.5349[illegible] 00	1.0136D 00	3.3135[illegible]-17	9.9018D-02	6.2434D-01	1.0000	1.4000

TIMINGS AT CYCLE 6 TIME = 5.[illegible]000-01

REZONE	TIMESTEP	CELL PLOT	LAYER PRNT	GRAPHICS	CHEMISTRY	DIFFUSION	CONDUCTION	ADINC
0.0000[illegible] 00	1.7[illegible]-03	1.2611[illegible]-01	4.0010[illegible]-02	0.0000 00	0.0000[illegible] 00	0.0000[illegible] 00	0.0000[illegible] 00	4.2212[illegible]-02

ADINC FREQUENCY COUNTERS (SINCE LAST CHECK) AT CYCLE 6
NO. CALLS = 5 NO. TIMESTEPS = 1 TOTAL NO. ITERATIONS = 3

LAYER BOUNDARY	INTER 1	INTER 2	INTER 3	INTER 4	INTER 5	INTER 6
INTERFACE POSITION	1.0000000[illegible]-20	1.0[illegible]000D 00				
INTERFACE VELOCITY	0.0000000[illegible] 00	3.3134750[illegible]-17				
INTERFACE AREA	1.0000000[illegible] 00	1.0000000[illegible] 00				

	TOTALS	SHELL 1	SHELL 2	SHELL 3	SHELL 4	SHELL 5
THERMAL ENG	2.5000349[illegible] 00	2.5000349[illegible] 00				
KINETIC ENG	1.3330[illegible]23[illegible]-08	1.3330[illegible]23D-08				
TOTAL ENG	2.5000[illegible]00[illegible] 00	2.5000[illegible]00D 00				
VOL AVG PRS	1.4000[illegible]00[illegible] 00	1.4000[illegible]00D 00				
VOL AVG DEN	1.0000[illegible]399[illegible] 00	1.0000[illegible]399D 00				
VOL AVG GAM	1.4000[illegible]00[illegible] 00	1.4000[illegible]00D 00				
VOL AVG ENT	6.2433941[illegible]-01	6.2433941[illegible]D-01				
VOL AVG PHPC	0.0000[illegible]00[illegible] 00	0.0000[illegible]00D 00				
LAYER VOLUME	1.0000[illegible]00[illegible] 00	1.0000[illegible]00D 00				
LAYER MASS	1.4000[illegible]00[illegible] 00	1.4000[illegible]00D 00				

AFTER STEP NO. 10 DT = 0.10000000D 00 THE TIME IS 0.10000000D 01

I	POSITION	VELOCITY	DENSITY	PRESSURE	ENERGY	AVG PRESS	AVG VELOC	CELL VOLUME	ENTROPY	THERAC	GAMMA
1	1.0000D-20	0.0000D 00	2.1399D 68	2.1399D 68	2.1399D 68	2.1399D 68	0.0000D 00	2.1399D 68	2.1399D 68	**********	
2	1.0004D-01	-3.1401D-03	1.3994D 00	9.9944D-01	2.4986D 00	9.9733D-01	-3.0407D-03	1.0004D-01	6.2434D-01	1.0000	1.4000
3	2.0007D-01	-5.9576D-03	1.3995D 00	9.9951D-01	2.4988D 00	9.9760D-01	-5.7708D-03	1.0004D-01	6.2434D-01	1.0000	1.4000
4	3.0010D-01	-8.1676D-03	1.3996D 00	9.9962D-01	2.4991D 00	9.9813D-01	-7.9154D-03	1.0003D-01	6.2434D-01	1.0000	1.4000
5	4.0012D-01	-9.5542D-03	1.3998D 00	9.9978D-01	2.4995D 00	9.9893D-01	-9.2648D-03	1.0002D-01	6.2434D-01	1.0000	1.4000
6	5.0012D-01	-9.9914D-03	1.3999D 00	9.9995D-01	2.4999D 00	9.9965D-01	-9.6950D-03	1.0000D-01	6.2434D-01	1.0000	1.4000
7	6.0011D-01	-9.4512D-03	1.4001D 00	1.0001D 00	2.5003D 00	1.0005D 00	-9.1766D-03	9.9992D-02	6.2434D-01	1.0000	1.4000
8	7.0010D-01	-8.0009D-03	1.4003D 00	1.0003D 00	2.5007D 00	1.0012D 00	-7.7727D-03	9.9982D-02	6.2434D-01	1.0000	1.4000
9	8.0007D-01	-5.7909D-03	1.4004D 00	1.0004D 00	2.5010D 00	1.0019D 00	-5.6282D-03	9.9973D-02	6.2434D-01	1.0000	1.4000
10	9.0004D-01	-3.0371D-03	1.4005D 00	1.0005D 00	2.5012D 00	1.0023D 00	-2.9525D-03	9.9967D-02	6.2434D-01	1.0000	1.4000
11	1.0000D 00	3.3135D-17	1.4005D 00	1.0005D 00	2.5012D 00	1.0026D 00	3.3135D-17	9.9964D-02	6.2434D-01	1.0000	1.4000

TIMINGS AT CYCLE 11 TIME = 1.0000D 00

REZONE	TIMESTEP	CELL PRINT	LAYER PRNT	GRAPHICS	CHEMISTRY	DIFFUSION	CONDUCTION	ADINC
0.0000D 00	3.2668D-03	2.5244D-01	8.0094D-02	0.0000D 00	0.0000D 00	0.0000D 00	0.0000D 00	8.2935D-02

ADINC FREQUENCY COUNTERS (SINCE LAST CHECK) AT CYCLE 11

NO. CALLS = 10 NO. TIMESTEPS = 1 TOTAL NO. ITERATIONS = 4

LAYER BOUNDARY	INTER 1	INTER 2	INTER 3	INTER 4	INTER 5	INTER 6
INTERFACE POSITION	1.0000000D-20	1.0000000D 00				
INTERFACE VELOCITY	0.0000000D 00	3.3134750D-17				
INTERFACE AREA	1.0000000D 00	1.0000000D 00				

	TOTALS	SHELL 1	SHELL 2	SHELL 3	SHELL 4	SHELL 5
THERMAL ENG	2.5000000D 00	2.5000000D 00				
KINETIC ENG	3.4948941D-05	3.4948941D-05				
TOTAL ENG	2.5000350D 00	2.5000350D 00				
VOL AVG RHO	1.4000000D 00	1.4000000D 00				
VOL AVG PRE	1.0000000D 00	1.0000000D 00				
VOL AVG GAM	1.4000000D 00	1.4000000D 00				
VOL AVG ENT	6.2433941D-01	6.2433941D-01				
VOL AVG RHOC	0.0000000D 00	0.0000000D 00				
LAYER VOLUME	1.0000000D 00	1.0000000D 00				
LAYER MASS	1.4000000D 00	1.4000000D 00				

AFTER STEP NO. 15 DT = 0.10000000D 00 THE TIME IS 0.15000000D 01

I	POSITION	VELOCITY	DENSITY	PRESSURE	ENERGY	AVG PRESS	AVG VELOC	CELL VOLUME	ENTROPY	THERAC	GAMMA
1	1.0000D-20	0.0000D 00	2.1399D 68	2.1399D 68	2.1399D 68	2.1399D 68	0.0000D 00	2.1399D 68	2.1399D 68	**********	**********
2	9.9016D-02	-1.0015D-04	1.4139D 00	1.0139D 00	2.5349D 00	1.0135D 00	-5.7988D-04	9.9016D-02	6.2434D-01	1.0000	1.4000
3	1.9813D-01	-2.1241D-04	1.4126D 00	1.0126D 00	2.5314D 00	1.0122D 00	-1.1214D-03	9.9111D-02	6.2434D-01	1.0000	1.4000
4	2.9742D-01	-3.3909D-04	1.4100D 00	1.0100D 00	2.5249D 00	1.0096D 00	-1.5826D-03	9.9294D-02	6.2434D-01	1.0000	1.4000
5	3.9697D-01	-4.6731D-04	1.4064D 00	1.0064D 00	2.5160D 00	1.0062D 00	-1.9176D-03	9.9546D-02	6.2434D-01	1.0000	1.4000
6	4.9681D-01	-5.7066D-04	1.4022D 00	1.0022D 00	2.5055D 00	1.0021D 00	-2.0819D-03	9.9842D-02	6.2434D-01	1.0000	1.4000
7	5.9696D-01	-6.1737D-04	1.3976D 00	9.9784D-01	2.4946D 00	9.9787D-01	-2.0414D-03	1.0015D-01	6.2434D-01	1.0000	1.4000
8	6.9742D-01	-5.8186D-04	1.3937D 00	9.9370D-01	2.4842D 00	9.9388D-01	-1.7826D-03	1.0045D-01	6.2434D-01	1.0000	1.4000
9	7.9812D-01	-4.5514D-04	1.3902D 00	9.9020D-01	2.4755D 00	9.9052D-01	-1.3216D-03	1.0071D-01	6.2434D-01	1.0000	1.4000
10	8.9901D-01	-2.5014D-04	1.3876D 00	9.8767D-01	2.4692D 00	9.8809D-01	-7.0364D-04	1.0089D-01	6.2434D-01	1.0000	1.4000
11	1.0000D 00	3.3135D-17	1.3863D 00	9.8634D-01	2.4658D 00	9.8682D-01	3.3135D-17	1.0099D-01	6.2434D-01	1.0000	1.4000

TIMINGS AT CYCLE 16 TIME = 1.5000D 00

REZONE	TIMESTEP	CELL PRINT	LAYER PRNT	GRAPHICS	CHEMISTRY	DIFFUSION	CONDUCTION	ADINC
0.0000D 00	4.7532D-03	3.7898D-01	1.2010D-01	0.0000D 00	0.0000D 00	0.0000D 00	0.0000D 00	1.2359D-01

ADINC FREQUENCY COUNTERS (SINCE LAST CHECK) AT CYCLE 16
NO. CALLS = 15 NO. TIMESTEPS = 1 TOTAL NO. ITERATIONS = 3

LAYER BOUNDARY	INTER 1	INTER 2	INTER 3	INTER 4	INTER 5	INTER 6
INTERFACE POSITION	1.0000000D-20	1.0000000D 00				
INTERFACE VELOCITY	0.0000000D 00	3.3134750D-17				
INTERFACE AREA	1.0000000D 00	1.0000000D 00				

	TOTALS	SHELL 1	SHELL 2	SHELL 3	SHELL 4	SHELL 5
THERMAL ERG	2.5000348D 00	2.5000348D 00				
KINETIC ERG	1.1925106D-07	1.1925108D-07				
TOTAL ERG	2.5000350D 00	2.5000350D 00				
VOL AVG RHO	1.4000000D 00	1.4000000D 00				
VOL AVG PRE	1.0000139D 00	1.0000139D 00				
VOL AVG GAM	1.4000000D 00	1.4000000D 00				
VOL AVG ENT	6.2433941D-01	6.2433941D-01				
VOL AVG RHOC	0.0000000D 00	0.0000000D 00				
LAYER VOLUME	1.0000000D 00	1.0000000D 00				
LAYER MASS	1.4000000D 00	1.4000000D 00				

AFTER STEP NO. 20 DT = 0.1000L0000 00 THE TIME IS 0.2000000E 01

I	POSITION	VELOCITY	DENSITY	PRESSURE	ENERGY	AVG PRESS	AVG VELOC	CELL VOLUME	ENTROPY	THERAC	GAMMA
1	1.0000D-20	0.0000D 00	2.1399D 68	2.1399D 68	2.1399D 68	2.1399D 68	0.0000E 00	2.1399E 68	2.1399E 68	**********	**********
2	9.9932D-02	2.9865D-03	1.4016D 00	1.0010D 00	2.5024D 00	1.0036D 00	2.8956E-03	9.9932D-02	6.2434D-01	1.0000	1.4000
3	1.9987D-01	5.7065D-03	1.4009D 00	1.0008D 00	2.5022D 00	1.0027D 00	5.5289E-03	9.9937D-02	6.2434D-01	1.0000	1.4000
4	2.9981D-01	7.9100D-03	1.4007D 00	1.0007D 00	2.5019D 00	1.0022D 00	7.6556E-03	9.9947D-02	6.2434D-01	1.0000	1.4000
5	3.9976D-01	9.3839D-03	1.4005D 00	1.0005D 00	2.5014D 00	1.0015D 00	9.0679D-03	9.9962D-02	6.2434D-01	1.0000	1.4000
6	4.9976D-01	9.9670D-03	1.4005D 00	1.0003D 00	2.5007D 00	1.0006D 00	9.6145D-03	9.9981D-02	6.2434D-01	1.0000	1.4000
7	5.9976D-01	9.5762D-03	1.3999D 00	9.9993D-01	2.4999D 00	9.9966D-01	9.2206D-03	1.0000D-01	6.2434D-01	1.0000	1.4000
8	6.9979D-01	8.2616D-03	1.3996D 00	9.9958D-01	2.4991D 00	9.9866D-01	7.9025D-03	1.0003D-01	6.2434D-01	1.0000	1.4000
9	7.9985D-01	6.0175D-03	1.3993D 00	9.9925D-01	2.4982D 00	9.9777D-01	5.7757D-03	1.0005D-01	6.2434D-01	1.0000	1.4000
10	8.9992D-01	3.1787D-03	1.3990D 00	9.9899D-01	2.4975D 00	9.9709D-01	3.0480D-03	1.0007D-01	6.2434D-01	1.0000	1.4000
11	1.0000D 00	3.3135D-17	1.3988D 00	9.9885D-01	2.4971D 00	9.9672D-01	3.3135D-17	1.0008D-01	6.2434D-01	1.0000	1.4000

TIMINGS AT CYCLE 21 TIME = 2.0000 00

REZONE	TIMESTEP	CELL PRINT	LAYER PRNT	GRAPHICS	CHEMISTRY	DIFFUSION	CONDUCTION	ADINC
0.0000E 00	0.2410D-03	5.0540E-01	1.0090D-01	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	1.6428D-01

ADINC FREQUENCY COUNTERS (SINCE LAST CHECK) AT CYCLE 21
NO. CALLS = 20 NO. TIMESTEPS = 1 TOTAL NO. ITERATIONS = 4

LAYER BOUNDARY	INTER 1	INTER 2	INTER 3	INTER 4	INTER 5	INTER 6
INTERFACE POSITION	1.0000E-20	1.0000D 00				
INTERFACE VELOCITY	0.0000E 00	3.3134750D-17				
INTERFACE AREA	1.0000E 00	1.0000D 00				

	TOTALS	SHELL 1	SHELL 2	SHELL 3	SHELL 4	SHELL 5
THERMAL ERG	2.5000E 00	2.5000E 00				
KINETIC ERG	3.4794E-05	3.4794E-05				
TOTAL ERG	2.5003E 00	2.5003E 00				
VOL AVG RHO	1.4000E 00	1.4000D 00				
VOL AVG PRE	1.0000E 00	1.0000D 00				
VOL AVG GAM	1.4000E 00	1.4000D 00				
VOL AVG ENT	6.2434E-01	6.2434D-01				
VOL AVG PHOC	0.0000E 00	0.0000D 00				
LAYER VOLUME	1.0000E 00	1.0000D 00				
LAYER MASS	1.4000E 00	1.4000D 00				

AFTER STEP NO. 21 DT = 0.10000000D 00 TOT TIME IS 0.21000000D 01

I	POSITION	VELOCITY	ENERGY	PRESSURE	ENERGY	AVG PRESS	AVG VELOC	CELL VOLUME	ENTROPY	THERMAC	GAMMA
1	1.0L00D-20	0.0000D 00	2.1399D 68	2.1399D 68	2.1399D 68	2.1399D 68	0.0000D 00	2.1399D 68	2.1399L 68	**********	
2	1.0023D-01	2.0052D-03	1.3966D 00	9.9684E-01	2.4992D 00	9.9991D-01	2.9456E-03	1.0023D-01	6.2434D-01	1.0000	1.4000
3	2.0043D-01	5.5529D-03	1.3971D 00	9.9714E-01	2.4992D 00	9.9991D-01	5.8297D-03	1.0020D-01	6.2434D-01	1.0000	1.4000
4	3.0066D-01	7.7017D-03	1.3977D 00	9.9771D-01	2.4993D 00	9.9992E-01	7.8061E-03	1.0016D-01	6.2434D-01	1.0000	1.4000
5	4.0076D-01	9.1432D-03	1.3985D 00	9.9850E-01	2.4993D 00	9.9992E-01	9.2035E-03	1.0011D-01	6.2434D-01	1.0000	1.4000
6	5.0074D-01	9.7208D-03	1.3995D 00	9.9945E-01	2.4987D 00	9.9960D-01	9.8439E-03	1.0004D-01	6.2434D-01	1.0000	1.4000
7	6.0071D-01	9.3500D-03	1.4005D 00	1.0005D 00	2.5012D 00	1.0002D 00	9.4831E-03	9.9967D-02	6.2434D-01	1.0000	1.4000
8	7.0060D-01	8.0365D-03	1.4015D 00	1.0015D 00	2.5037D 00	1.0005D 00	8.1291E-03	9.9890D-02	6.2434D-01	1.0000	1.4000
9	8.0044D-01	5.8079D-03	1.4025D 00	1.0025D 00	2.5056D 00	1.0008D 00	5.9527D-03	9.9830D-02	6.2434D-01	1.0000	1.4000
10	9.0023D-01	3.1123D-03	1.4029D 00	1.0029D 00	2.5073D 00	1.0011D 00	3.1455E-03	9.9791E-02	6.2434L-01	1.0000	1.4000
11	1.0000D 00	3.3135E-17	1.4033D 00	1.0033D 00	2.5081D 00	1.0011D 00	3.3135E-17	9.9768E-02	6.2434E-01	1.0000	1.4000

TIMINGS AT CYCLE 22 TIME = 2.10000 00

REZONE	TIMESTEP	CELL PRINT	LAYER PRNT	GRAPHICS	CHEMISTRY	DIFFUSION	CONDUCTION	ADINC
0.0000L 00	6.5376L-03	5.3809L-01	1.6813D-01	0.0000L 00	0.0000L 00	0.0000L 00	0.0000L 00	1.7152D-01

ADINC FREQUENCY COUNTERS (SINCE LAST CHECK) AT CYCLE 22
NO. CALLS = 21 NO. TIMESTEPS = 1 TOTAL NO. ITERATIONS = 3

LAYER BOUNDARY	INTER 1	INTER 2	INTER 3	INTER 4	INTER 5	INTER 6
INTERFACE POSITION	1.0000000L-20	1.0000000D 00				
INTERFACE VELOCITY	0.0000000L 00	3.3134750D-17				
INTERFACE AREA	1.0000000L 00	1.0000000D 00				

	TOTALS	SHELL 1	SHELL 2	SHELL 3	SHELL 4	SHELL 5
THERMAL ENG	2.5000L69L 00	2.5000L89D 00				
KINETIC ENG	3.3113104 3L-05	3.3113104 3D-05				
TOTAL ENG	2.5000350 0L 00	2.5000350 0D 00				
VOL AVG ENG	1.4000000 0L 00	1.4000000 0D 00				
VOL AVG ENE	1.0000075 0L 00	1.0000075 0D 00				
VOL AVG GAM	1.4000000 0L 00	1.4000000 0D 00				
VOL AVG ENT	6.2433941 1L-01	6.2433941 1D-01				
VOL AVG PRSL	0.0000000 0L 00	0.0000000 0D 00				
LAYER VOLUME	1.0000000 0L 00	1.0000000 0D 00				
LAYER MASS	1.4000000 0L 00	1.4000000 0D 00				

AFTER STEP NO. 25 DT = 4.1[illegible]E-08 THE TIME IS 4.2500[illegible]E-01

I	POSITION	VELOCITY	DENSITY	PRESSURE	ENERGY	AVG PRESS	AVG VELOC	CELL VOLUME	ENTHPY	THERMAC	GAMMA
1	1.0[illegible]E-20	0.0[illegible]E+00	2.1[illegible]E+01	2.1[illegible]E+01	2.1[illegible]E+01	2.1[illegible]E+01	0.0[illegible]E+00	2.1[illegible]E+01	2.1[illegible]E+01	**********	**********
2	1.0[illegible]E-01	4.0[illegible]E-04	1.3[illegible]E+01	9.5[illegible]E-01	2.4[illegible]E+00	9.8[illegible]E-01	8.3[illegible]E-04	1.0[illegible]E-01	6.2434[illegible]E-01	1.4000	1.4000
3	2.0[illegible]E-01	7.3[illegible]E-04	1.3[illegible]E+00	9.7[illegible]E-01	2.4[illegible]E+00	9.8[illegible]E-01	1.5[illegible]E-03	1.0[illegible]E-01	6.2434[illegible]E-01	1.4000	1.4000
4	3.0[illegible]E-01	9.5[illegible]E-04	1.3[illegible]E+00	9.9[illegible]E-01	2.4[illegible]E+00	9.9[illegible]E-01	2.1[illegible]E-03	1.0[illegible]E-01	6.2434[illegible]E-01	1.4000	1.4000
5	4.0[illegible]E-01	1.0[illegible]E-03	1.3[illegible]E+00	9.9[illegible]E-01	2.4[illegible]E+00	9.9[illegible]E-01	2.4[illegible]E-03	1.0[illegible]E-01	6.2434[illegible]E-01	1.4000	1.4000
6	5.0[illegible]E-01	9.5[illegible]E-04	1.3[illegible]E+00	9.9[illegible]E-01	2.4[illegible]E+00	9.9[illegible]E-01	2.4[illegible]E-03	1.0[illegible]E-01	6.2434[illegible]E-01	1.4000	1.4000
7	6.0[illegible]E-01	7.9[illegible]E-04	1.0[illegible]E+00	1.0[illegible]E+00	2.5[illegible]E+00	1.0[illegible]E+00	2.2[illegible]E-03	9.9[illegible]E-02	6.2434[illegible]E-01	1.4000	1.4000
8	7.0[illegible]E-01	5.8[illegible]E-04	1.0[illegible]E+00	1.0[illegible]E+00	2.5[illegible]E+00	1.0[illegible]E+00	1.8[illegible]E-03	9.9[illegible]E-02	6.2434[illegible]E-01	1.4000	1.4000
9	8.0[illegible]E-01	3.8[illegible]E-04	1.0[illegible]E+00	1.0[illegible]E+00	2.5[illegible]E+00	1.0[illegible]E+00	1.2[illegible]E-03	9.9[illegible]E-02	6.2434[illegible]E-01	1.4000	1.4000
10	9.0[illegible]E-01	1.7[illegible]E-04	1.0[illegible]E+00	1.0[illegible]E+00	2.5[illegible]E+00	1.0[illegible]E+00	5.4[illegible]E-04	9.9[illegible]E-02	6.2434[illegible]E-01	1.4000	1.4000
11	1.0[illegible]E+00	3.3135[illegible]E-17	1.0[illegible]E+00	1.0[illegible]E+00	2.5[illegible]E+00	1.0[illegible]E+00	3.3135[illegible]E-17	9.9[illegible]E-02	6.2434[illegible]E-01	1.4000	1.4000

TIMINGS AT CYCLE 26 TIME = 4.50000E-01

FREQNE	TIMESTEP	CELL FIELD	LAYER PROP	GRAPHICS	CHEMISTRY	DIFFUSION	CONDUCTION	ACINC
0.0000E+00	7.7251E-03	0.31[illegible]E-01	2.[illegible]E-01	0.[illegible]E+00	0.0000E+00	0.0000E+00	0.0000E+00	4.1495E-01

ADINC FREQUENCY COUNTERS (SINCE LAST CHECK) AT CYCLE 26

NO. CALLS = 25 NO. TIMESTEPS = 1 TOTAL NO. ITERATIONS = 91

LAYER BOUNDARY	INTER 1	INTER 2	INTER 3	INTER 4	INTER 5	INTER 6
INTERFACE POSITION	1.0000000[illegible]E-20	1.0000000[illegible]E+00				
INTERFACE VELOCITY	0.0000000[illegible]E+00	3.313475[illegible]E-17				
INTERFACE AREA	1.0000000[illegible]E+00	1.0000000[illegible]E+00				

	TOTALS	SHELL 1	SHELL 2	SHELL 3	SHELL 4	SHELL 5
THERMAL ENG	2.5000[illegible]E+00	2.5000[illegible]E+00				
KINETIC ENG	3.27[illegible]E-07	3.27[illegible]E-07				
TOTAL ENG	2.5000[illegible]E+00	2.5000[illegible]E+00				
VOL AVG PRS	1.4000[illegible]E+00	1.4000[illegible]E+00				
VOL AVG ENE	1.0000[illegible]E+00	1.0000[illegible]E+00				
VOL AVG GAM	1.4000[illegible]E+00	1.4000[illegible]E+00				
VOL AVG ENT	6.2433[illegible]E-01	6.2433[illegible]E-01				
VOL AVG ENPC	0.0000[illegible]E+00	0.0000[illegible]E+00				
LAYER VOLUME	1.0000[illegible]E+00	1.0000[illegible]E+00				
LAYER MASS	1.4000[illegible]E+00	1.4000[illegible]E+00				

Appendix D
STANDARD TEST #2

```
1                AN INCOMPRESSIBLE SLUG BETWEEN ADIABATIC GASES
2
3     &CONTRL
4          DTMIN=1.0D0, DTMAX=1.0D0,
5     &END
6     &SHLINI
7          NSHELL=3, DVEL=0.0D0,
8     &END
9     &SHLDAT
10         LCELLS=5,  RN=1.0D0, VN=1.0D-3, MATERS=1.01D0, GAMMAS=1.4D0,
11         RHOS=1.4D0, RHOCS=0.0D0, PRES=1.0D0,
12    &END
13    &SHLDAT
14         LCELLS=5,  RN=2.0D0, VN=1.0D-3, MATERS=2.02D0, GAMMAS=0.5D0,
15         POWS=1.0D0, RHOCS=1.4D2, PRES=1.0D0, RHOS=1.4000000000014D2,
16    &END
17    &SHLDAT
18         LCELLS=5,  RN=3.0D0, VN=0.0D0, MATERS=3.01D0, GAMMAS=1.4D0,
19         RHOS=1.4D0, RHOCS=0.0D0, PRES=1.0D0,
20    &END
```

```
NAMELIST /CONTRL/  DEFAULTS ...
&CONTRL
MAXSTP=          20,IPRINT=          1,ALPHA =          1,DTMIN =      0.1000000000000000,DTMAX =      0.1000000000000000,N     =
      10,EPSRO =      0.5000000000000000,EPSVO =      0.5000000000000000,
GEOMCO=      1.0000000000000000,      0.0000000000000000,      0.0000000000000000,      0.0000000000000000,      0.0000000000000000,
LZONE =          F,LCHEM =          F,LDIFF =          F,LTCND =          F,LTPRT =          T,MDAMP =          1,
&END

NAMELIST /CONTRL/  UPDATES ...
&CONTRL
MAXSTP=          20,IPRINT=          1,ALPHA =          1,DTMIN =      1.0000000000000000,DTMAX =      1.0000000000000000,N     =
      10,EPSRO =      0.5000000000000000,EPSVO =      0.5000000000000000,
GEOMCO=      1.0000000000000000,      0.0000000000000000,      0.0000000000000000,      0.0000000000000000,      0.0000000000000000,
LZONE =          F,LCHEM =          F,LDIFF =          F,LTCND =          F,LTPRT =          T,MDAMP =          1,
&END

NAMELIST /SHLINI/  DEFAULTS ...
&SHLINI
NSHELL=          1,RN    = 0.1000000000000000D-19,VI.    =      0.0000000000000000,MODE  =          1,DEPO  =      0.0000000000000000,
DVEL  = 0.1000000000000000D-01,
&END

NAMELIST /SHLINI/  UPDATES ...
&SHLINI
NSHELL=          3,RN    = 0.1000000000000000D-19,VI.    =      0.0000000000000000,MODE  =          1,DEPO  =      0.0000000000000000,
DVEL  =      0.0000000000000000,
&END

NAMELIST /SHLDAT/  DATA FOR LAYER 1
&SHLDAT
LCELLS=          5,RN    =      1.0000000000000000,VI.    = 0.1000000000000000D-02,MATERS=      1.0100000000000000,GAMMAS=
     1.4000000000000000,RHOS  =      1.4000000000000000,PRES  =      1.0000000000000000,PRES  =      1.0000000000000000,PHOCS =
     0.0000000000000000,
&END

NAMELIST /SHLDAT/  DATA FOR LAYER 2
&SHLDAT
LCELLS=          5,RN    =      2.0000000000000000,VI.    = 0.1000000000000000D-02,MATERS=      2.0200000000000000,GAMMAS=
     0.5000000000000000,RHOS  =      140.0000000001400,PRES  =      1.0000000000000000,PRES  =      1.0000000000000000,PHOCS =
      140.0000000000000,
&END

NAMELIST /SHLDAT/  DATA FOR LAYER 3
&SHLDAT
LCELLS=          5,RN    =      3.0000000000000000,VI.    =      0.0000000000000000,MATERS=      3.0100000000000000,GAMMAS=
     1.4000000000000000,RHOS  =      1.4000000000000000,PRES  =      1.0000000000000000,PRES  =      1.0000000000000000,PHOCS =
     0.0000000000000000,
&END
```

AFTER STEP NO. 0 DT = 0.10000000D 01 THE TIME IS 0.00000000D 00

I	POSITION	VELOCITY	DENSITY	PRESSURE	ENERGY	AVG PRESS	AVG VELOC	CELL VOLUME	ENTROPY	THFRAC	GAMMA
1	1.0000D-20	0.0000D 00	2.1399D 68	2.1399D 68	2.1399D 68	2.1399D 68	2.1399D 68	2.1399D 68	2.1399D 68	**********	**********
2	2.0000D-01	2.0000D-04	1.4000D 00	1.0000D 00	2.5000D 00	2.1399D 68	2.1399D 68	2.0000D-01	6.2434D-01	1.0000	1.4000
3	4.0000D-01	4.0000D-04	1.4000D 00	1.0000D 00	2.5000D 00	2.1399D 68	2.1399D 68	2.0000D-01	6.2434D-01	1.0000	1.4000
4	6.0000D-01	6.0000D-04	1.4000D 00	1.0000D 00	2.5000D 00	2.1399D 68	2.1399D 68	2.0000D-01	6.2434D-01	1.0000	1.4000
5	8.0000D-01	8.0000D-04	1.4000D 00	1.0000D 00	2.5000D 00	2.1399D 68	2.1399D 68	2.0000D-01	6.2434D-01	1.0000	1.4000
6	1.0000D 00	1.0000D-03	1.4000D 00	1.0000D 00	2.5000D 00	2.1399D 68	2.1399D 68	2.0000D-01	6.2434D-01	1.0000	1.4000
7	1.2000D 00	1.0000D-03	1.4000D 02	1.0000D 00	7.0000D-05	2.1399D 68	2.1399D 68	2.0000D-01	8.4516D 04	0.0000	0.5000
8	1.4000D 00	1.0000D-03	1.4000D 02	1.0000D 00	7.0000D-05	2.1399D 68	2.1399D 68	2.0000D-01	8.4516D 04	0.0000	0.5000
9	1.6000D 00	1.0000D-03	1.4000D 02	1.0000D 00	7.0000D-05	2.1399D 68	2.1399D 68	2.0000D-01	8.4516D 04	0.0000	0.5000
10	1.8000D 00	1.0000D-03	1.4000D 02	1.0000D 00	7.0000D-05	2.1399D 68	2.1399D 68	2.0000D-01	8.4516D 04	0.0000	0.5000
11	2.0000D 00	1.0000D-03	1.4000D 02	1.0000D 00	7.0000D-05	2.1399D 68	2.1399D 68	2.0000D-01	8.4516D 04	0.0000	0.5000
12	2.2000D 00	8.0000D-04	1.4000D 00	1.0000D 00	2.5000D 00	2.1399D 68	2.1399D 68	2.0000D-01	6.2434D-01	1.0000	1.4000
13	2.4000D 00	6.0000D-04	1.4000D 00	1.0000D 00	2.5000D 00	2.1399D 68	2.1399D 68	2.0000D-01	6.2434D-01	1.0000	1.4000
14	2.6000D 00	4.0000D-04	1.4000D 00	1.0000D 00	2.5000D 00	2.1399D 68	2.1399D 68	2.0000D-01	6.2434D-01	1.0000	1.4000
15	2.8000D 00	2.0000D-04	1.4000D 00	1.0000D 00	2.5000D 00	2.1399D 68	2.1399D 68	2.0000D-01	6.2434D-01	1.0000	1.4000
16	3.0000D 00	1.3878D-20	1.4000D 00	1.0000D 00	2.5000D 00	2.1399D 68	2.1399D 68	2.0000D-01	6.2434D-01	1.0000	1.4000

TIMINGS AT CYCLE 1 TIME = 0.0000D 00

REZONE	TIMESTEP	CELL PRINT	LAYER PRNT	GRAPHICS	CHEMISTRY	DIFFUSION	CONDUCTION	ADINC
0.0000D 00	3.5120D-04	0.0000D 00	0.0000D 00	0.0000D 00	0.0000D 00	0.0000D 00	0.0000D 00	0.0000D 00

ADINC FREQUENCY COUNTERS (SINCE LAST CHECK) AT CYCLE 1

NO. CALLS = 0 NO. TIMESTEPS = 0 TOTAL NO. ITERATIONS = 0

LAYER BOUNDARY	INTER 1	INTER 2	INTER 3	INTER 4	INTER 5	INTER 6
INTERFACE POSITION	1.0000000D-20	1.0000000D 00	2.0000000D 00	3.0000000D 00		
INTERFACE VELOCITY	0.0000000D 00	1.0000000D-03	1.0000000D-03	1.3877878D-20		
INTERFACE AREA	1.0000000D 00	1.0000000D 00	1.0000000D 00	1.0000000D 00		

	TOTALS	SHELL 1	SHELL 2	SHELL 3	SHELL 4	SHELL 5
THERMAL ERG	5.0000000D 00	2.5000000D 00	6.6635859D-13	2.5000000D 00		
KINETIC ERG	7.6476000D-05	2.3800000D-07	7.6000000D-05	2.3800000D-07		
TOTAL ERG	5.0007648D 00	2.5000024D 00	7.6000007D-05	2.5000024D 00		
VOL AVG RHO	4.7600000D 01	1.4000000D 00	1.4000000D 02	1.4000000D 00		
VOL AVG PRE	1.0000000D 00	1.0000000D 00	1.0000000D 00	1.0000000D 00		
VOL AVG GAM	1.1010000D 00	1.4000000D 00	5.0000000D-01	1.4000000D 00		
VOL AVG ENT	2.8172402D 04	6.2433941D-01	8.4515958D 04	6.2433941D-01		
VOL AVG PHOT	4.6666667D 01	0.0000000D 00	1.4000000D 02	0.0000000D 00		
LAYER VOLUME	3.0000000D 00	1.0000000D 00	1.0000000D 00	1.0000000D 00		
LAYER MASS	1.4280000D 02	1.4000000D 00	1.4000000D 02	1.4000000D 00		

AFTER STEP NO. 5 DT = 0.10000000D 01 THE TIME IS 0.50000000D 01

I	POSITION	VELOCITY	DENSITY	PRESSURE	ENERGY	AVG PRESS	AVG VELOC	CELL VOLUME	ENTROPY	THFRAC	GAMMA
1	1.00000D-20	0.00000 00	2.13990 68	2.13990 68	2.13990 68	2.13990 68	0.00000 00	2.13990 68	2.13990 68**********	******	
2	2.00920D-01	1.53780D-04	1.39360 00	9.93590D-01	2.48400 00	9.94150-01	1.61720D-04	2.00920D-01	6.2434D-01	1.0000	1.4000
3	4.01840D-01	3.07040D-04	1.39360 00	9.93590D-01	2.48400 00	9.94150-01	3.23170D-04	2.00920D-01	6.2434D-01	1.0000	1.4000
4	6.02760D-01	4.59560D-04	1.39360 00	9.93600D-01	2.48400 00	9.9416D-01	4.84120D-04	2.00920D-01	6.2434D-01	1.0000	1.4000
5	8.03680D-01	6.11230D-04	1.39360 00	9.93620D-01	2.48410 00	9.9418D-01	6.44440D-04	2.00920D-01	6.2434D-01	1.0000	1.4000
6	1.00460 00	7.62540D-04	1.39360 00	9.93640D-01	2.48410 00	9.9419D-01	8.04130D-04	2.00910D-01	6.2434D-01	1.0000	1.4000
7	1.20460 00	7.62540D-04	1.40000 02	9.94930D-01	4.07020D-05	9.9537D-01	8.04130D-04	2.0000D-01	8.4516D 04	0.0000	0.5000
8	1.40460 00	7.62540D-04	1.40000 02	9.97480D-01	4.07020D-05	9.9770D-01	8.04130D-04	2.0000D-01	8.4516D 04	0.0000	0.5000
9	1.60460 00	7.62540D-04	1.40000 02	1.00000 00	4.07020D-05	1.0000D 00	8.04130D-04	2.0000D-01	8.4516D 04	0.0000	0.5000
10	1.80460 00	7.62540D-04	1.40000 02	1.00200 00	4.07020D-05	1.0024D 00	8.04130D-04	2.0000D-01	8.4516D 04	0.0000	0.5000
11	2.00460 00	7.62540D-04	1.40000 02	1.00510 00	4.07020D-05	1.0047D 00	8.04130D-04	2.0000D-01	8.4516D 04	0.0000	0.5000
12	2.20370 00	6.11190D-04	1.40640 00	1.00640 00	2.51610 00	1.0059D 00	6.44441D-04	1.9909D-01	6.2434D-01	1.0000	1.4000
13	2.40280 00	4.59440D-04	1.40640 00	1.00650 00	2.51610 00	1.0059D 00	4.84080D-04	1.9908D-01	6.2434D-01	1.0000	1.4000
14	2.60180 00	3.06960D-04	1.40650 00	1.00650 00	2.51620 00	1.0059D 00	3.23140D-04	1.9908D-01	6.2434D-01	1.0000	1.4000
15	2.80090 00	1.53740D-04	1.40650 00	1.00650 00	2.51620 00	1.0059D 00	1.61700D-04	1.9908D-01	6.2434D-01	1.0000	1.4000
16	3.00000 00	1.38780D-20	1.40650 00	1.00650 00	2.51620 00	1.0059D 00	1.38780D-20	1.9908D-01	6.2434D-01	1.0000	1.4000

TIMINGS AT CYCLE 6 TIME = 5.00000 00

REZONE	TIMESTEP	CELL PRINT	LAYER PRNT	GRAPHICS	CHEMISTRY	DIFFUSION	CONDUCTION	ADINC
0.00000 00	2.10930-03	1.75670-01	5.09750-02	0.00000 00	0.00000 00	0.00000 00	0.00000 00	4.25800-02

ADINC FREQUENCY COUNTERS (SINCE LAST CHECK) AT CYCLE 6
NO. CALLS = 5 NO. TIMESTEPS = 1 TOTAL NO. ITERATIONS = 3

LAYER BOUNDARY	INTER 1	INTER 2	INTER 3	INTER 4	INTER 5	INTER 6
INTERFACE POSITION	1.00000000D-20	1.00458997D 00	2.00458997D 00	3.00000000D 00		
INTERFACE VELOCITY	0.00000000D 00	7.62535018D-04	7.62535018D-04	1.38777878D-20		
INTERFACE AREA	1.00000000D 00	1.00000000D 00	1.00000000D 00	1.00000000D 00		

	TOTALS	SHELL 1	SHELL 2	SHELL 3	SHELL 4	SHELL 5
THERMAL ERG	5.00006950D 00	2.49542472D 00	6.84310300-13	2.50460477D 00		
KINETIC ERG	4.09603052D-05	1.39075008D-07	4.07021750-05	1.39053787D-07		
TOTAL ERG	5.00007048D 00	2.49542486D 00	4.07021765D-05	2.50460491D 00		
VOL AVG PHO	4.76000000D 01	1.39360340D 00	1.40000000D 02	1.40645559D 00		
VOL AVG PRE	1.00001572D 00	9.93600249D-01	1.00003530 00	1.00646154D 00		
VOL AVG GAM	1.10000000D 00	1.00000000D 00	5.00000000D-01	1.40000000D 00		
VOL AVG ENT	2.81724923D 04	6.24339411D-01	8.45159582D 04	6.24339411D-01		
VOL AVG PHOL	4.66666667D 01	0.00000000D 00	1.40000000D 02	0.00000000D 00		
LAYER VOLUME	3.00000000D 00	1.00458997D 00	1.00000000D 00	9.95410027D-01		
LAYER MASS	1.42000000D 02	1.40000000D 00	1.40000000D 02	1.40000000D 00		

AFTER STEP NO. 10 DT = 0.10000000D 01 THE TIME IS 0.10000000D 02

I	POSITION	VELOCITY	DENSITY	PRESSURE	ENERGY	AVG PRESS	AVG VELOC	CELL VOLUME	ENTROPY	THFRAC	GAMMA
1	1.0000D-20	0.0000D 00	2.1399D 68	2.1399D 68	2.1399D 68	2.1399D 68	0.0000D 00	2.1399D 68	2.1399D 68	**********	**********
2	2.0140D-01	3.2453D-05	1.3902D 00	9.9025D-01	2.4756D 00	9.9041D-01	4.5998D-05	2.0140D-01	6.2434D-01	1.0000	1.4000
3	4.0281D-01	6.4856D-05	1.3902D 00	9.9026D-01	2.4756D 00	9.9042D-01	9.2136D-05	2.0140D-01	6.2434D-01	1.0000	1.4000
4	6.0421D-01	9.7278D-05	1.3903D 00	9.9027D-01	2.4757D 00	9.9043D-01	1.3844D-04	2.0140D-01	6.2434D-01	1.0000	1.4000
5	8.0561D-01	1.2999D-04	1.3903D 00	9.9030D-01	2.4757D 00	9.9046D-01	1.8486D-04	2.0140D-01	6.2434D-01	1.0000	1.4000
6	1.0070D 00	1.6294D-04	1.3903D 00	9.9033D-01	2.4758D 00	9.9049D-01	2.3132D-04	2.0139D-01	6.2434D-01	1.0000	1.4000
7	1.2070D 00	1.6294D-04	1.4000D 02	9.9229D-01	1.8585D-06	9.9242D-01	2.3132D-04	2.0000D-01	8.4516D 04	0.0000	0.5000
8	1.4070D 00	1.6294D-04	1.4000D 02	9.9619D-01	1.8585D-06	9.9625D-01	2.3132D-04	2.0000D-01	8.4516D 04	0.0000	0.5000
9	1.6070D 00	1.6294D-04	1.4000D 02	1.0001D 00	1.8585D-06	1.0001D 00	2.3132D-04	2.0000D-01	8.4516D 04	0.0000	0.5000
10	1.8070D 00	1.6294D-04	1.4000D 02	1.0040D 00	1.8585D-06	1.0039D 00	2.3132D-04	2.0000D-01	8.4516D 04	0.0000	0.5000
11	2.0070D 00	1.6294D-04	1.4000D 02	1.0079D 00	1.8585D-06	1.0077D 00	2.3132D-04	2.0000D-01	8.4516D 04	0.0000	0.5000
12	2.2056D 00	1.3004D-04	1.4096D 00	1.0098D 00	2.5246D 00	1.0097D 00	1.8485D-04	1.9861D-01	6.2434D-01	1.0000	1.4000
13	2.4042D 00	9.7361D-05	1.4099D 00	1.0099D 00	2.5247D 00	1.0097D 00	1.3843D-04	1.9860D-01	6.2434D-01	1.0000	1.4000
14	2.6028D 00	6.4944D-05	1.4099D 00	1.0099D 00	2.5247D 00	1.0097D 00	9.2134D-05	1.9860D-01	6.2434D-01	1.0000	1.4000
15	2.8014D 00	3.2511D-05	1.4099D 00	1.0099D 00	2.5248D 00	1.0097D 00	4.5999D-05	1.9860D-01	6.2434D-01	1.0000	1.4000
16	3.0000D 00	1.3878D-20	1.4099D 00	1.0099D 00	2.5248D 00	1.0097D 00	1.3878D-20	1.9860D-01	6.2434D-01	1.0000	1.4000

TIMINGS AT CYCLE 11 TIME = 1.0000D 01

REZONE	TIMESTEP	CELL PRINT	LAYER PRNT	GRAPHICS	CHEMISTRY	DIFFUSION	CONDUCTION	ADINC
0.0000D 00	3.8655D-03	3.5138D-01	1.1793D-01	0.0000D 00	0.0000D 00	0.0000D 00	0.0000D 00	8.5156D-02

ADINC FREQUENCY COUNTERS (SINCE LAST CHECK) AT CYCLE 11
NO. CALLS = 10 NO. TIMESTEPS = 1 TOTAL NO. ITERATIONS = 3

LAYER BOUNDARY	INTER 1	INTER 2	INTER 3	INTER 4	INTER 5	INTER 6
INTERFACE POSITION	1.0000000D-20	1.0070001D 00	2.0070001D 00	3.0000000D 00		
INTERFACE VELOCITY	0.0000000D 00	1.6293923D-04	1.6293923D-04	1.3877787D-20		
INTERFACE AREA	1.0000000D 00	1.0000000D 00	1.0000000D 00	1.0000000D 00		

	TOTALS	SHELL 1	SHELL 2	SHELL 3	SHELL 4	SHELL 5
THERMAL ERG	5.0000868D 00	2.4930340D 00	6.6954454D-13	2.5070346D 00		
KINETIC ERG	1.8710338D-06	6.2652862D-09	1.8584570D-06	6.2915509D-09		
TOTAL ERG	5.0000704BD 00	2.4930340ID 00	1.8584569D-06	2.5070346ID 00		
VOL AVG RHO	4.7600L000D 01	1.3906797D 00	1.4000000D 02	1.4098692D 00		
VOL AVG PRE	1.0000366ID 00	9.9628152D-01	1.0000823D 00	1.0098313D 00		
VOL AVG GAM	1.1000000D 00	1.4000000D 00	5.0000000D-01	1.4000000D 00		
VOL AVG ENT	2.8172402D 04	6.2433941ID-01	8.4515958D 04	6.2433941D-01		
VOL AVG RHOC	4.6666667L 01	0.0000000D 00	1.4000000D 02	0.0000000D 00		
LAYER VOLUME	3.0000000L 00	1.0070001D 00	1.0000000D 00	9.9299892D-01		
LAYER MASS	1.4280000L 02	1.4000000D 00	1.4000000D 02	1.4000000D 00		

AFTER STEP NO. 15 DT = 0.10000000D 01 THE TIME IS 0.15000000D 02

I	POSITION	VELOCITY	DENSITY	PRESSURE	ENERGY	AVG PRESS	AVG VELOC	CELL VOLUME	ENTROPY	THERMAC	GAMMA
1	1.00000D-20	0.00000D 00	2.13990D 68	2.13990D 68	2.13990D 68	2.13990D 68	0.00000D 00	2.13990D 68	2.13990D 68	**********	**********
2	2.01220D-01	-1.02990D-04	1.39150D 00	9.91510D-01	2.47880D 00	9.91200D-01	-9.02370D-05	2.01220D-01	6.24340D-01	1.0000	1.4000
3	4.02440D-01	-2.00120D-04	1.39150D 00	9.91520D-01	2.47880D 00	9.91210D-01	-1.80500D-04	2.01220D-01	6.24340D-01	1.0000	1.4000
4	6.03660D-01	-3.09210D-04	1.39150D 00	9.91530D-01	2.47880D 00	9.91220D-01	-2.70850D-04	2.01220D-01	6.24340D-01	1.0000	1.4000
5	8.04870D-01	-4.11850D-04	1.39150D 00	9.91560D-01	2.47890D 00	9.91240D-01	-3.61120D-04	2.01220D-01	6.24340D-01	1.0000	1.4000
6	1.00610D 00	-5.14000D-04	1.39160D 00	9.91580D-01	2.47900D 00	9.91270D-01	-4.51370D-04	2.01210D-01	6.24340D-01	1.0000	1.4000
7	1.20610D 00	-5.14000D-04	1.40000D 02	9.93290D-01	1.84980D-05	9.93050D-01	-4.51370D-04	2.00000D-01	8.45160D 04	0.0000	0.5000
8	1.40610D 00	-5.14000D-04	1.40000D 02	9.96640D-01	1.84980D-05	9.96560D-01	-4.51370D-04	2.00000D-01	8.45160D 04	0.0000	0.5000
9	1.60610D 00	-5.14000D-04	1.40000D 02	1.00010D 00	1.84980D-05	1.00010D 00	-4.51370D-04	2.00000D-01	8.45160D 04	0.0000	0.5000
10	1.80610D 00	-5.14000D-04	1.40000D 02	1.00340D 00	1.84980D-05	1.00360D 00	-4.51370D-04	2.00000D-01	8.45160D 04	0.0000	0.5000
11	2.00610D 00	-5.14000D-04	1.40000D 02	1.00680D 00	1.84980D-05	1.00710D 00	-4.51370D-04	2.00000D-01	8.45160D 04	0.0000	0.5000
12	2.20490D 00	-4.11950D-04	1.40850D 00	1.00850D 00	2.52140D 00	1.00890D 00	-3.61220D-04	1.98790D-01	6.24340D-01	1.0000	1.4000
13	2.40370D 00	-3.09360D-04	1.40860D 00	1.00860D 00	2.52140D 00	1.00890D 00	-2.71880D-04	1.98780D-01	6.24340D-01	1.0000	1.4000
14	2.60240D 00	-2.00280D-04	1.40860D 00	1.00860D 00	2.52150D 00	1.00890D 00	-1.80540D-04	1.98780D-01	6.24340D-01	1.0000	1.4000
15	2.80120D 00	-1.03090D-04	1.40860D 00	1.00860D 00	2.52150D 00	1.00890D 00	-9.02570D-05	1.98780D-01	6.24340D-01	1.0000	1.4000
16	3.00000D 00	1.36780D-20	1.40860D 00	1.00860D 00	2.52150D 00	1.00890D 00	1.36780D-20	1.98780D-01	6.24340D-01	1.0000	1.4000

TIMINGS AT CYCLE 16 TIME = 1.50000D 01

REZONE	TIMESTEP	CELL PRINT	LAYER PRNT	GRAPHICS	CHEMISTRY	DIFFUSION	CONDUCTION	ADINC
0.00000D 00	5.61980D-03	5.27180D-01	1.76790D-01	0.00000D 00	0.00000D 00	0.00000D 00	0.00000D 00	1.25720D-01

ADINC FREQUENCY COUNTERS (SINCE LAST CHECK) AT CYCLE 16
NO. CALLS = 15 NO. TIMESTEPS = 1 TOTAL NO. ITERATIONS = 3

LAYER BOUNDARY	INTER 1	INTER 2	INTER 3	INTER 4	INTER 5	INTER 6
INTERFACE POSITION	1.00000000D-20	1.00608571D 00	2.00608571D 00	3.00000000D 00		
INTERFACE VELOCITY	0.00000000D 00	-5.14057927D-04	-5.14057927D-04	1.38777878D-20		
INTERFACE AREA	1.00000000D 00	1.00000000D 00	1.00000000D 00	1.00000000D 00		

	TOTALS	SHELL 1	SHELL 2	SHELL 3	SHELL 4	SHELL 5
THERMAL ERG	5.00005185D 00	2.49394009D 00	6.69121781D-13	2.50611176D 00		
KINETIC ERG	1.66240525D-05	6.30625093D-08	1.84978886D-05	6.31013431D-08		
TOTAL ERG	5.00073408D 00	2.49394616D 00	1.84978893D-05	2.50611182D 00		
VOL AVG RHO	4.76000000D 01	1.39153155D 00	1.40000000D 02	1.40857216D 00		
VOL AVG PRE	1.00002766D 00	9.91541806D-01	1.00006225D 00	1.00858264D 00		
VOL AVG GAM	1.10000000D 00	1.40010000D 00	5.00000000D-01	1.40000000D 00		
VOL AVG ENT	2.61724023D 04	6.24339411D-01	8.45159582D 04	6.24339411D-01		
VOL AVG RHOC	4.66666667D 01	0.00000000D 00	1.40000000D 02	0.00000000D 00		
LAYER VOLUME	3.00000000D 00	1.00608571D 00	1.00000000D 00	9.93914294D-01		
LAYER MASS	1.42800000D 02	1.40010000D 00	1.40000000D 02	1.40000000D 00		

AFTER STEP NO. 20 DT = 0.10000000D-01 THE TIME IS 0.20000000D-02

I	POSITION	VELOCITY	DENSITY	PRESSURE	ENERGY	AVG PRESS	AVG VELOC	CELL VOLUME	ENTROPY	THERMAC	GAMMA
1	1.00000D-20	0.00000D 00	2.13990D 00	2.13990D 00	2.13990D 00	2.13990D 00	0.00000 00	2.13990D 00	2.13990D 00	**********	
2	2.00460D-01	-1.89460D-04	1.39680D 00	9.96810D-01	2.49920D 00	9.96160D-01	-1.84740D-04	2.00460D-01	6.24340D-01	1.0000	1.4000
3	4.00910D-01	-3.79180D-04	1.39680D 00	9.96810D-01	2.49920D 00	9.96170D-01	-3.69220D-04	2.00460D-01	6.24340D-01	1.0000	1.4000
4	6.01370D-01	-5.68870D-04	1.39680D 00	9.96810D-01	2.49920D 00	9.96170D-01	-5.53290D-04	2.00460D-01	6.24340D-01	1.0000	1.4000
5	8.01830D-01	-7.58150D-04	1.39680D 00	9.96820D-01	2.49920D 00	9.96180D-01	-7.38610D-04	2.00460D-01	6.24340D-01	1.0000	1.4000
6	1.00230D 00	-9.46900D-04	1.39680D 00	9.96830D-01	2.49910D 00	9.96190D-01	-9.19670D-04	2.00450D-01	6.24340D-01	1.0000	1.4000
7	1.20230D 00	-9.46900E-04	1.40000D 02	9.97470D-01	6.27640D-05	9.98960D-01	-9.19670D-04	2.00000D-01	6.45160D 04	0.0000	0.5000
8	1.40230D 00	-9.46900E-04	1.40000D 02	9.98740D-01	6.27640D-05	9.99490D-01	-9.19670D-04	2.00000D-01	6.45160D 04	0.0000	0.5000
9	1.60230D 00	-9.46900D-04	1.40000D 02	1.00000D 00	6.27640D-05	1.00000D 00	-9.19670D-04	2.00000D-01	6.45160D 04	0.0000	0.5000
10	1.80230D 00	-9.46900D-04	1.40000D 02	1.00130D 00	6.27640D-05	1.00150D 00	-9.19670D-04	2.00000D-01	6.45160D 04	0.0000	0.5000
11	2.00230D 00	-9.46900D-04	1.40000D 02	1.00250D 00	6.27640D-05	1.00310D 00	-9.19670D-04	2.00000D-01	6.45160D 04	0.0000	0.5000
12	2.20180D 00	-7.58010D-04	1.40320D 00	1.00320D 00	2.50890D 00	1.00380D 00	-7.38710D-04	1.99550D-01	6.24340D-01	1.0000	1.4000
13	2.40140D 00	-5.68640D-04	1.40320D 00	1.00320D 00	2.50890D 00	1.00380D 00	-5.53140D-04	1.99540D-01	6.24340D-01	1.0000	1.4000
14	2.60090D 00	-3.78930D-04	1.40320D 00	1.00320D 00	2.50890D 00	1.00390D 00	-3.69060D-04	1.99540D-01	6.24340D-01	1.0000	1.4000
15	2.80050D 00	-1.89360D-04	1.40320D 00	1.00320D 00	2.50890D 00	1.00390D 00	-1.84630D-04	1.99540D-01	6.24340D-01	1.0000	1.4000
16	3.00000D 00	1.38780E-20	1.40320D 00	1.00320D 00	2.50890D 00	1.00390D 00	1.38780E-20	1.99540D-01	6.24340D-01	1.0000	1.4000

TIMINGS AT CYCLE 21 TIME = 2.00000 01

REZONE	TIMESTEP	CELL PRINT	LAYER PRNT	GRAPHICS	CHEMISTRY	DIFFUSION	CONDUCTION	ADINC
0.00000 00	7.37066E-03	7.03125E-01	2.35580D-01	0.00000 00	0.00000 00	0.00000 00	0.00000 00	1.68300D-01

ADINC FREQUENCY COUNTERS (SINCE LAST CHECK) AT CYCLE 21
NO. CALLS = 20 NO. TIMESTEPS = 1 TOTAL NO. ITERATIONS = 3

LAYER BOUNDARY	INTER 1	INTER 2	INTER 3	INTER 4	INTER 5	INTER 6
INTERFACE POSITION	1.00000000E-20	1.00228108D 00	2.00228108D 00	3.00000000D 00		
INTERFACE VELOCITY	0.00000000D 00	-0.46904359D-04	-0.46904359D-04	1.38777878D-20		
INTERFACE AREA	1.00000000D 00	1.00000000D 00	1.00000000D 00	1.00000000D 00		

	TOTALS	SHELL 1	SHELL 2	SHELL 3	SHELL 4	SHELL 5
THERMAL ENG	5.00000728E 00	2.49772655D 00	6.67340718E-13	2.50228473D 00		
KINETIC ENG	6.31912375D-05	2.13695087D-07	6.27639506D-05	2.13591916D-07		
TOTAL ENG	5.00007048E 00	2.49772777D 00	6.27639512D-05	2.50228405D 00		
VOL AVG RHO	4.76100000E 01	1.39681375D 00	1.40000000E 02	1.40320082D 00		
VOL AVG PRE	1.00000386E 00	9.96815201D-01	1.00000686E 00	1.00320228D 00		
VOL AVG GAM	1.10000000E 00	1.40000000D 00	5.00000000E-01	1.40000000D 00		
VOL AVG ENT	2.61724062E 04	6.24339411D-01	8.45159502E 04	6.24339411D-01		
VOL AVG PROC	4.66666667E 01	0.00000000D 00	1.40000000E 02	0.00000000D 00		
LAYER VOLUME	3.00000000E 00	1.00228108D 00	1.00000000E 00	9.97718916D-01		
LAYER MASS	1.42800000E 02	1.40000000D 00	1.40000000D 02	1.40000000D 00		

AFTER STEP NO. 22 DT = 0.10000000D 01 THE TIME IS 0.22000000D 02

I	POSITION	VELOCITY	DENSITY	PRESSURE	ENERGY	AVG PRESS	AVG VELOC	CELL VOLUME	ENTROPY	THERMAC	GAMMA
1	1.0000D-20	0.0000D 00	2.1399D 68	2.1399D 68	2.1399D 68	2.1399D 68	0.0000D 00	2.1399D 68	2.1399D 68	**********	**********
2	2.0007D-01	-2.0121D-04	1.3995D 00	9.9954D-01	2.4989D 00	9.9885D-01	-1.9899D-04	2.0007D-01	6.2434D-01	1.0000	1.4000
3	4.0013D-01	-4.0190D-04	1.3995D 00	9.9954D-01	2.4989D 00	9.9885D-01	-3.9766D-04	2.0007D-01	6.2434D-01	1.0000	1.4000
4	6.0020D-01	-6.0181D-04	1.3995D 00	9.9954D-01	2.4989D 00	9.9885D-01	-5.9594D-04	2.0007D-01	6.2434D-01	1.0000	1.4000
5	8.0026D-01	-8.0076D-04	1.3995D 00	9.9955D-01	2.4989D 00	9.9885D-01	-7.9388D-04	2.0006D-01	6.2434D-01	1.0000	1.4000
6	1.0003D 00	-9.9693D-04	1.3995D 00	9.9955D-01	2.4989D 00	9.9886D-01	-9.9178D-04	2.0006D-01	6.2434D-01	1.0000	1.4000
7	1.2003D 00	-9.9693D-04	1.4000D 02	9.9964D-01	6.9850D-05	9.9990D-01	-9.9078D-04	2.0000D-01	8.4516D 04	0.0000	0.5000
8	1.4003D 00	-9.9693D-04	1.4000D 02	9.9982D-01	6.9850D-05	9.9995D-01	-9.9078D-04	2.0000D-01	8.4516D 04	0.0000	0.5000
9	1.6003D 00	-9.9693D-04	1.4000D 02	1.0000D 00	6.9850D-05	1.0000D 00	-9.9078D-04	2.0000D-01	8.4516D 04	0.0000	0.5000
10	1.8003D 00	-9.9893D-04	1.4000D 02	1.0002D 00	6.9850D-05	1.0005D 00	-9.9078D-04	2.0000D-01	8.4516D 04	0.0000	0.5000
11	2.0003D 00	-9.9893D-04	1.4000D 02	1.0004D 00	6.9850D-05	1.0009D 00	-9.9078D-04	2.0000D-01	8.4516D 04	0.0000	0.5000
12	2.2003D 00	-8.0080D-04	1.4005D 00	1.0005D 00	2.5011D 00	1.0011D 00	-7.9375D-04	1.9994D-01	6.2434D-01	1.0000	1.4000
13	2.4002D 00	-6.0185D-04	1.4005D 00	1.0005D 00	2.5011D 00	1.0011D 00	-5.9606D-04	1.9993D-01	6.2434D-01	1.0000	1.4000
14	2.6001D 00	-4.0192D-04	1.4005D 00	1.0005D 00	2.5011D 00	1.0012D 00	-3.9788D-04	1.9993D-01	6.2434D-01	1.0000	1.4000
15	2.8001D 00	-2.0120D-04	1.4005D 00	1.0005D 00	2.5011D 00	1.0012D 00	-1.9907D-04	1.9993D-01	6.2434D-01	1.0000	1.4000
16	3.0000D 00	1.3878D-20	1.4005D 00	1.0005D 00	2.5011D 00	1.0012D 00	1.3878D-20	1.9993D-01	6.2434D-01	1.0000	1.4000

TIMINGS AT CYCLE 23 TIME = 2.20000 01

REZONE	TIMESTEP	CELL PRINT	LAYER PRNT	GRAPHICS	CHEMISTRY	DIFFUSION	CONDUCTION	ADINC
0.0000D 00	8.0783D-03	7.7354D-01	2.5914D-01	0.0000D 00	0.0000D 00	0.0000D 00	0.0000D 00	1.8535D-01

ADINC FREQUENCY COUNTERS (SINCE LAST CHECK) AT CYCLE 23
NO. CALLS = 22 NO. TIMESTEPS = 1 TOTAL NO. ITERATIONS = 3

LAYER BOUNDARY	INTER 1	INTER 2	INTER 3	INTER 4	INTER 5	INTER 6
INTERFACE POSITION	1.0000000D-20	1.0003255D 00	2.0003255D 00	3.0000000D 00		
INTERFACE VELOCITY	0.0000000D 00	-9.9893092D-04	-9.9893092D-04	1.3877787D-20		
INTERFACE AREA	1.0000000D 00	1.0000000D 00	1.0000000D 00	1.0000000D 00		

	TOTALS	SHELL 1	SHELL 2	SHELL 3	SHELL 4	SHELL 5
THERMAL ERG	5.0000015D 00	2.4996745D 00	6.6489367D-13	2.5003256D 00		
KINETIC ERG	7.6327640D-05	2.3660710D-07	6.9850409D-05	2.3824229D-07		
TOTAL ERG	5.0000784D 00	2.4996747D 00	6.9850409D-05	2.5003258D 00		
VOL AVG RHO	4.7610000D 01	1.3995444D 00	1.4000000D 02	1.4004559D 00		
VOL AVG PRE	1.0000014D 00	9.9954434D-01	1.0000003E 00	1.0004559D 00		
VOL AVG GAM	1.1000000D 00	1.4000000D 00	5.0000000E-01	1.4000000D 00		
VOL AVG ENT	2.8172402D 04	6.2433941D-01	6.4515956D 04	6.2433941D-01		
VOL AVG RHOC	4.6666667D 01	0.0000000D 00	1.4000000D 02	0.0000000D 00		
LAYER VOLUME	3.0000000D 00	1.0003255D 00	1.0000000D 00	0.9996744D-01		
LAYER MASS	1.4280000D 02	1.4000000D 00	1.4000000D 02	1.4000000D 00		

AFTER STEP NO. 23 DT = 0.10000000D 01 THE TIME IS 0.23000000D 02

I	POSITION	VELOCITY	DENSITY	PRESSURE	ENERGY	AVG PRESS	AVG VELOC	CELL VOLUME	ENTROPY	THERAC	GAMMA
1	1.0000D-20	0.0000D 00	2.1399D 68	2.1399D 68	2.1399D 68	2.1399D 68	0.0000D 00	2.1399D 68	2.1399D 68	**********	
2	1.9987D-01	-1.9943D-04	1.4009D 00	1.0009D 00	2.5024D 00	1.0002D 00	-2.0032D-04	1.9987D-01	6.2434D-01	1.0000	1.4000
3	3.9973D-01	-3.9906D-04	1.4009D 00	1.0009D 00	2.5024D 00	1.0002D 00	-4.0045D-04	1.9987D-01	6.2434D-01	1.0000	1.4000
4	5.9960D-01	-5.9839D-04	1.4009D 00	1.0009D 00	2.5024D 00	1.0002D 00	-6.0058D-04	1.9987D-01	6.2434D-01	1.0000	1.4000
5	7.9946D-01	-7.9732D-04	1.4009D 00	1.0009D 00	2.5023D 00	1.0002D 00	-7.9984D-04	1.9987D-01	6.2434D-01	1.0000	1.4000
6	9.9933D-01	-9.9550D-04	1.4009D 00	1.0009D 00	2.5023D 00	1.0002D 00	-9.9722D-04	1.9987D-01	6.2434D-01	1.0000	1.4000
7	1.1993D 00	-9.9550D-04	1.4000D 02	1.0007D 00	6.9372D-05	1.0002D 00	-9.9722D-04	2.0000D-01	8.4516D 04	0.0000	0.5000
8	1.3993D 00	-9.9550D-04	1.4000D 02	1.0004D 00	6.9372D-05	1.0001D 00	-9.9722D-04	2.0000D-01	8.4516D 04	0.0000	0.5000
9	1.5993D 00	-9.9550D-04	1.4000D 02	1.0000D 00	6.9372D-05	1.0000D 00	-9.9722D-04	2.0000D-01	8.4516D 04	0.0000	0.5000
10	1.7993D 00	-9.9550D-04	1.4000D 02	9.9963D-01	6.9372D-05	9.9998D-01	-9.9722D-04	2.0000D-01	8.4516D 04	0.0000	0.5000
11	1.9993D 00	-9.9550D-04	1.4000D 02	9.9925D-01	6.9372D-05	9.9981D-01	-9.9722D-04	2.0000D-01	8.4516D 04	0.0000	0.5000
12	2.1995D 00	-7.9716D-04	1.3991D 00	9.9907D-01	2.4977D 00	9.9976D-01	-7.9898D-04	2.0013D-01	6.2434D-01	1.0000	1.4000
13	2.3996D 00	-5.9812D-04	1.3991D 00	9.9906D-01	2.4977D 00	9.9976D-01	-5.9999D-04	2.0013D-01	6.2434D-01	1.0000	1.4000
14	2.5997D 00	-3.9875D-04	1.3991D 00	9.9906D-01	2.4976D 00	9.9976D-01	-4.0034D-04	2.0013D-01	6.2434D-01	1.0000	1.4000
15	2.7999D 00	-1.9929D-04	1.3991D 00	9.9906D-01	2.4976D 00	9.9976D-01	-2.0025D-04	2.0013D-01	6.2434D-01	1.0000	1.4000
16	3.0000D 00	1.3678D-20	1.3991D 00	9.9906D-01	2.4976D 00	9.9976D-01	1.3678D-20	2.0013D-01	6.2434D-01	1.0000	1.4000

TIMINGS AT CYCLE 24 TIME = 2.30000 01

REZONE	TIMESTEP	CELL PRINT	LAYER PRNT	GRAPHICS	CHEMISTRY	DIFFUSION	CONDUCTION	ADINC
0.0000D 00	8.4290D-03	8.0873D-01	2.7094D-01	0.0000D 00	0.0000D 00	0.0000D 00	0.0000D 00	1.9382D-01

ADINC FREQUENCY COUNTERS (SINCE LAST CHECK) AT CYCLE 24
NO. CALLS = 23 NO. TIMESTEPS = 1 TOTAL NO. ITERATIONS = 3

LAYER BOUNDARY	INTER 1	INTER 2	INTER 3	INTER 4	INTER 5	INTER 6
INTERFACE POSITION	1.0000000D-20	9.9932831SD-01	1.999328310 00	3.0000000D 00		
INTERFACE VELOCITY	0.0000000D 00	-9.9550248 9D-04	-9.9550248 9D-04	1.38777878D-20		
INTERFACE AREA	1.0000000D 00	1.0000000D 00	1.0000000D 00	1.0000000D 00		

	TOTALS	SHELL 1	SHELL 2	SHELL 3	SHELL 4	SHELL 5
THERMAL ERG	5.0000000 30 00	2.5000720D 00	6.6622949D-13	2.499328630 00		
KINETIC ERG	6.98443647L-05	2.36358251D-07	6.93717644D-05	2.3e242027D-07		
TOTAL ERG	5.0000704 8L 00	2.50067224D 00	6.93717651D-05	2.499328870 00		
VOL AVG RHO	4.760000000 01	1.400940990 00	1.40000000D 02	1.399066270 00		
VOL AVG PRE	1.000006321 00	1.000941120 00	1.00000071D 00	9.99060398D-01		
VOL AVG GAM	1.100000001 00	1.40000000D 00	5.00000000D-01	1.40000000D 00		
VOL AVG ENT	2.817240230 04	6.24339411D-01	8.45159582D 04	6.24339411D-01		
VOL AVG RHOL	4.666666670 01	0.00000000D 00	1.40000000D 02	0.00000000D 00		
LAYER VOLUME	3.000000000 00	9.99328315D-01	1.000000001 00	1.00067169D 00		
LAYER MASS	1.428000000 02	1.40000000D 00	1.40000000D 02	1.40000000D 00		

AFTER STEP NO. 25 DT = 0.10000000 01 THE TIME IS 0.25000000 02

I	POSITION	VELOCITY	DENSITY	PRESSURE	ENERGY	AVG PRESS	AVG VELOC	CELL VOLUME	ENTHALPY	THERMAC	GAMMA
1	1.00000-20	0.00000 00	2.13990 00	2.13990 00	2.13990 00	2.13990 00	0.00000 00	2.13990 00	2.13990 00	**********	
2	1.99480-01	-1.87100-04	1.40370 00	1.00370 00	2.50920 00	1.00370 00	-1.87480-04	1.99480-01	6.24340-01	1.0000	1.4000
3	3.96950-01	-3.74000-04	1.40370 00	1.00370 00	2.50920 00	1.00370 00	-3.74150-04	1.99480-01	6.24340-01	1.0000	1.4000
4	5.96430-01	-5.60340-04	1.40370 00	1.00370 00	2.50920 00	1.00370 00	-5.71660-04	1.99480-01	6.24340-01	1.0000	1.4000
5	7.97910-01	-7.45640-04	1.40370 00	1.00370 00	2.50910 00	1.00370 00	-7.61870-04	1.99480-01	6.24340-01	1.0000	1.4000
6	9.97390-01	-9.30040-04	1.40360 00	1.00360 00	2.50910 00	1.00360 00	-9.51220-04	1.99480-01	6.24340-01	1.0000	1.4000
7	1.19740 00	-9.30040-04	1.40000 02	1.00290 00	6.05480-05	1.00240 00	-9.51220-04	2.00000-01	6.45160 04	0.0000	0.5000
8	1.39740 00	-9.30040-04	1.40000 02	1.00150 00	6.05480-05	1.00120 00	-9.51220-04	2.00000-01	6.45160 04	0.0000	0.5000
9	1.59740 00	-9.30040-04	1.40000 02	1.00000 00	6.05480-05	1.00000 00	-9.51220-04	2.00000-01	6.45160 04	0.0000	0.5000
10	1.79740 00	-9.30040-04	1.40000 02	9.98560-01	6.05480-05	9.98420-01	-9.51220-04	2.00000-01	6.45160 04	0.0000	0.5000
11	1.99740 00	-9.30040-04	1.40000 02	9.97110-01	6.05480-05	9.97640-01	-9.51220-04	2.00000-01	6.45160 04	0.0000	0.5000
12	2.19790 00	-7.45750-04	1.39640 00	9.96360-01	2.49090 00	9.97040-01	-7.61980-04	2.00520-01	6.24340-01	1.0000	1.4000
13	2.39840 00	-5.60490-04	1.39640 00	9.96370-01	2.49090 00	9.97030-01	-5.72130-04	2.00520-01	6.24340-01	1.0000	1.4000
14	2.59900 00	-3.74190-04	1.39640 00	9.96360-01	2.49090 00	9.97020-01	-3.81750-04	2.00520-01	6.24340-01	1.0000	1.4000
15	2.79950 00	-1.87170-04	1.39640 00	9.96350-01	2.49090 00	9.97020-01	-1.91980-04	2.00520-01	6.24340-01	1.0000	1.4000
16	3.00000 00	1.38780-20	1.39630 00	9.96350-01	2.49090 00	9.97020-01	1.38780-20	2.00520-01	6.24340-01	1.0000	1.4000

TIMINGS AT CYCLE 26 TIME = 2.50000 01

REZONE	TIMESTEP	CELL PRINT	LAYER PRNT	GRAPHICS	CHEMISTRY	DIFFUSION	CONDUCTION	ADINC
0.0000 00	9.13200-03	8.79130-01	2.94480-01	0.0000 00	0.0000 00	0.0000 00	0.0000 00	2.10790-01

ADINC FREQUENCY COUNTERS (SINCE LAST CHECK) AT CYCLE 26
NO. CALLS = 25 NO. TIMESTEPS = 1 TOTAL NO. ITERATIONS = 3

LAYER BOUNDARY	INTER 1	INTER 2	INTER 3	INTER 4	INTER 5	INTER 6
INTERFACE POSITION	1.00000000-20	9.97393153D-01	1.99739315D 00	3.00000000 00		
INTERFACE VELOCITY	0.00000000 00	-9.30040241D-04	-9.30040241D-04	1.38777878-20		
INTERFACE AREA	1.00000000 00	1.00000000D 00	1.00000000D 00	1.00000000 00		

	TOTALS	SHELL 1	SHELL 2	SHELL 3	SHELL 4	SHELL 5
THERMAL ERG	5.00000951D 00	2.50261161D 00	6.74765178-13	2.49739790 00		
KINETIC ERG	6.09619670D-05	2.08832219D-07	6.05482395D-05	2.06852480-07		
TOTAL ERG	5.00007048D 00	2.50261182D 00	6.05482402D-05	2.49739811D 00		
VOL AVG RHO	4.76000000D 01	1.40365912D 00	1.40000000D 02	1.39635990D 00		
VOL AVG PRE	1.00000513D 00	1.00366104D 00	1.00001158D 00	9.96361797D-01		
VOL AVG GAM	1.10000000D 00	1.40000000D 00	5.00000000D-01	1.40000000D 00		
VOL AVG ENT	2.81724023D 04	6.24339411D-01	8.45159582D 04	6.24339411D-01		
VOL AVG RHOC	4.66666667D 01	0.00000000D 00	1.40000000D 02	0.00000000D 00		
LAYER VOLUME	3.00000000D 00	9.97393153D-01	1.00000000D 00	1.00260685D 00		
LAYER MASS	1.42800000D 02	1.40010000D 00	1.40000000D 02	1.40000000D 00		

Appendix E
STANDARD TEST #3

```
1                    A LINUS SIMULATION
2
3     &CONTRL
4          DTMIN=1.0D-7, DTMAX=1.0D-4,
5          EPSP0=0.45D0, EPSV0=0.45D0,
6          MAXSTP=1001, IPRINT=50,
7          ALPHA=2, MDAMP=10,
8     &END
9     &SHLINI
10         NSHELL=5, DVEL=0.0D0,
11    &END
12    &SHLDAT
13         LCELLS=3,  RN=10.0D0, VN=0.0D-3, MATERS=1.01D0, GAMMAS=1.6667D0,
14         RHOS=1.2D-3, RHOCS=0.0D0, PRES=1.0D6,
15    &END
16    &SHLDAT
17         LCELLS=2,  RN=15.0D0, VN=0.0D-3, MATERS=2.02D0, GAMMAS=2.0000D0,
18         RHOS=1.2D-3, RHOCS=0.0D0, PRES=1.0D6,
19    &END
20    &SHLDAT
21         LCELLS=15, RN=30.0D0, VN=0.0D-3, MATERS=3.03D0, GAMMAS=0.5000D0,
22         POWS=2.0D0, RHOCS=1.0D0, PRES=1.0D6, RHOS=1.000000000010D0,
23    &END
24    &SHLDAT
25         LCELLS=5,  RN=35.0D0, VN=0.0D-3, MATERS=4.04D0, GAMMAS=0.5000D0,
26         POWS=1.5D0, RHOCS=7.8D0, PRES=1.0D6, RHOS=7.800000000078D0,
27    &END
28    &SHLDAT
29         LCELLS=5,  RN=40.0D0, VN=0.0D-3, MATERS=5.05D0, GAMMAS=1.4000D0,
30         RHOS=1.2D-1, RHOCS=0.0D0, PRES=1.0D8, POWS=1.0D0,
31    &END
```

```
NAMELIST /CONTRL/  DEFAULTS ...
&CONTRL
MAXSTP=         20,IPRINT=          1,ALPHA =          1,DTMIN =      0.1000000000000000,DTMAX =      0.1000000000000000,N      =
        10,EPSRO =      0.5000000000000000,EPSVO =      0.5000000000000000,
GEOMCO=       1.0000000000000000,      0.0000000000000000,      0.0000000000000000,      0.0000000000000000,      0.0000000000000000,
LZONE =          F,LCHEM =          F,LDIFF =          F,LTCND =          F,LTPRT =          T,MDAMP =          1,
&END

NAMELIST /CONTRL/  UPDATES  ...
&CONTRL
MAXSTP=       1001,IPRINT=         50,ALPHA =          2,DTMIN = 0.1000000000000000D-06,DTMAX = 0.1000000000000000D-03,N      =
        10,EPSRO =      0.4500000000000000,EPSVO =      0.4500000000000000,
GEOMCO=       1.0000000000000000,      0.0000000000000000,      0.0000000000000000,      0.0000000000000000,      0.0000000000000000,
LZONE =          F,LCHEM =          F,LDIFF =          F,LTCND =          F,LTPRT =          T,MDAMP =         10,
&END

NAMELIST /SHLINI/  DEFAULTS ...
&SHLINI
NSHELL=          1,RN    = 0.1000000000000000D-19,VN    =      0.0000000000000000,MODE  =          1,DRHO  =      0.0000000000000000,
DVEL  = 0.1000000000000000D-01,
&END

NAMELIST /SHLINI/  UPDATES  ...
&SHLINI
NSHELL=          5,RN    = 0.1000000000000000D-19,VN    =      0.0000000000000000,MODE  =          1,DRHO  =      0.0000000000000000,
DVEL  =      0.0000000000000000,
&END

NAMELIST /SHLDAT/  DATA FOR LAYER 1.
&SHLDAT
LCELLS=          3,RN    =      9.9999999999999999,VN    =      0.0000000000000000,MATERS=      1.0100000000000000,GAMMAS=
      1.6667000000000000,RHOS  = 0.1200000000000000D-02,PRES  =      1.0000000000000000,PPES  =      999999.9999999999,RHOCS =
      0.0000000000000000,
&END

NAMELIST /SHLDAT/  DATA FOR LAYER 2
&SHLDAT
LCELLS=          2,RN    =      14.999999999999999,VN    =      0.0000000000000000,MATERS=      2.0200000000000000,GAMMAS=
      2.0000000000000000,RHOS  = 0.1200000000000000D-02,PRES  =      1.0000000000000000,PRES  =      999999.9999999999,RHOCS =
      0.0000000000000000,
&END

NAMELIST /SHLDAT/  DATA FOR LAYER 3
&SHLDAT
LCELLS=         15,RN    =      30.000000000000000,VN    =      0.0000000000000000,MATERS=      3.0300000000000000,GAMMAS=
      0.5000000000000000,RHOS  =      1.0000000000100000,PRES  =      2.0000000000000000,PPES  =      999999.9999999999,RHOCS =
      1.0000000000000000,
&END

NAMELIST /SHLDAT/  DATA FOR LAYER 4
&SHLDAT
LCELLS=          5,RN    =      35.000000000000000,VN    =      0.0000000000000000,MATERS=      4.0399999999999999,GAMMAS=
      0.5000000000000000,RHOS  =      7.8000000000779999,PRES  =      1.5000000000000000,PRES  =      999999.9999999999,RHOCS =
      7.7999999999999999,
&END

NAMELIST /SHLDAT/  DATA FOR LAYER 5
&SHLDAT
LCELLS=          5,RN    =      40.000000000000000,VN    =      0.0000000000000000,MATERS=      5.0499999999999999,GAMMAS=
      1.4000000000000000,RHOS  =      0.1200000000000000,PRES  =      1.0000000000000000,PRES  =      10000000.0000000,RHOCS =
      0.0000000000000000,
```

```
&END

 AFTER STEP NO.     0  DT =   0.34785054D-05  THE TIME IS   0.00000000D 00

  I   POSITION     VELOCITY      DENSITY      PRESSURE      ENERGY      AVG PRESS     AVG VELOC   CELL VOLUME     ENTROPY     THFRAC    GAMMA
  1  1.0000D-20  0.0000D 00  2.1399D 68  2.1399D 68  2.1399D 68  2.1399D 68  2.1399D 68  2.1399D 68  2.1399D 68**************
  2  3.3333D 00  0.0000D 00  1.2000D-03  1.0000D 06  1.4999D 06  2.1399D 68  2.1399D 68  3.4907D 01  7.3812D 10  1.0000  1.6667
  3  6.6667D 00  0.0000D 00  1.2000D-03  1.0000D 06  1.4999D 06  2.1399D 68  2.1399D 68  1.0472D 02  7.3812D 10  1.0000  1.6667
  4  1.0000D 01  0.0000D 00  1.2000D-03  1.0000D 06  1.4999D 06  2.1399D 68  2.1399D 68  1.7453D 02  7.3812D 10  1.0000  1.6667
  5  1.2500D 01  0.0000D 00  1.2000D-03  1.0000D 06  1.0000D 06  2.1399D 68  2.1399D 68  1.7671D 02  6.9444D 11  1.0000  2.0000
  6  1.5000D 01  0.0000D 00  1.2000D-03  1.0000D 06  1.0000D 06  2.1399D 68  2.1399D 68  2.1598D 02  6.9444D 11  1.0000  2.0000
  7  1.5067D 01  0.0000D 00  1.0000D 00  1.0000D 06  6.6666D-05  2.1399D 68  2.1399D 68  6.2071D 00  1.0000D 11  1.0000  0.5000
  8  1.5267D 01  0.0000D 00  1.0000D 00  1.0000D 06  6.6666D-05  2.1399D 68  2.1399D 68  1.9059D 01  1.0000D 11  1.0000  0.5000
  9  1.5600D 01  0.0000D 00  1.0000D 00  1.0000D 06  6.6666D-05  2.1399D 68  2.1399D 68  3.2323D 01  1.0000D 11  1.0000  0.5000
 10  1.6067D 01  0.0000D 00  1.0000D 00  1.0000D 06  6.6666D-05  2.1399D 68  2.1399D 68  4.6426D 01  1.0000D 11  1.0000  0.5000
 11  1.6667D 01  0.0000D 00  1.0000D 00  1.0000D 06  6.6666D-05  2.1399D 68  2.1399D 68  6.1701D 01  1.0000D 11  1.0000  0.5000
 12  1.7400D 01  0.0000D 00  1.0000D 00  1.0000D 06  6.6666D-05  2.1399D 68  2.1399D 68  7.8484D 01  1.0000D 11  1.0000  0.5000
 13  1.8267D 01  0.0000D 00  1.0000D 00  1.0000D 06  6.6666D-05  2.1399D 68  2.1399D 68  9.7110D 01  1.0000D 11  1.0000  0.5000
 14  1.9267D 01  0.0000D 00  1.0000D 00  1.0000D 06  6.6666D-05  2.1399D 68  2.1399D 68  1.1791D 02  1.0000D 11  1.0000  0.5000
 15  2.0400D 01  0.0000D 00  1.0000D 00  1.0000D 06  6.6666D-05  2.1399D 68  2.1399D 68  1.4123D 02  1.0000D 11  1.0000  0.5000
 16  2.1667D 01  0.0000D 00  1.0000D 00  1.0000D 06  6.6666D-05  2.1399D 68  2.1399D 68  1.6740D 02  1.0000D 11  1.0000  0.5000
 17  2.3067D 01  0.0000D 00  1.0000D 00  1.0000D 06  6.6666D-05  2.1399D 68  2.1399D 68  1.9675D 02  1.0000D 11  1.0000  0.5000
 18  2.4600D 01  0.0000D 00  1.0000D 00  1.0000D 06  6.6666D-05  2.1399D 68  2.1399D 68  2.2962D 02  1.0000D 11  1.0000  0.5000
 19  2.6267D 01  0.0000D 00  1.0000D 00  1.0000D 06  6.6666D-05  2.1399D 68  2.1399D 68  2.6634D 02  1.0000D 11  1.0000  0.5000
 20  2.8067D 01  0.0000D 00  1.0000D 00  1.0000D 06  6.6666D-05  2.1399D 68  2.1399D 68  3.0725D 02  1.0000D 11  1.0000  0.5000
 21  3.0000D 01  0.0000D 00  1.0000D 00  1.0000D 06  6.6666D-05  2.1399D 68  2.1399D 68  3.5268D 02  1.0000D 11  1.0000  0.5000
 22  3.0447D 01  0.0000D 00  7.8000D 00  1.0000D 06  6.6666D-05  2.1399D 68  2.1399D 68  8.4926D 01  3.5806D 10  1.0000  0.5000
 23  3.1265D 01  0.0000D 00  7.8000D 00  1.0000D 06  6.6666D-05  2.1399D 68  2.1399D 68  1.5853D 02  3.5806D 10  1.0000  0.5000
 24  3.2324D 01  0.0000D 00  7.8000D 00  1.0000D 06  6.6666D-05  2.1399D 68  2.1399D 68  2.1153D 02  3.5806D 10  1.0000  0.5000
 25  3.3578D 01  0.0000D 00  7.8000D 00  1.0000D 06  6.6666D-05  2.1399D 68  2.1399D 68  2.5961D 02  3.5806D 10  1.0000  0.5000
 26  3.5000D 01  0.0000D 00  7.8000D 00  1.0000D 06  6.6666D-05  2.1399D 68  2.1399D 68  3.0642D 02  3.5806D 10  1.0000  0.5000
 27  3.6000D 01  0.0000D 00  1.2000D-01  1.0000D 08  2.5000D 08  2.1399D 68  2.1399D 68  2.2305D 02  1.9460D 09  1.0000  1.4000
 28  3.7000D 01  0.0000D 00  1.2000D-01  1.0000D 08  2.5000D 08  2.1399D 68  2.1399D 68  2.2934D 02  1.9460D 09  1.0000  1.4000
 29  3.8000D 01  0.0000D 00  1.2000D-01  1.0000D 08  2.5000D 08  2.1399D 68  2.1399D 68  2.3562D 02  1.9460D 09  1.0000  1.4000
 30  3.9000D 01  0.0000D 00  1.2000D-01  1.0000D 08  2.5000D 08  2.1399D 68  2.1399D 68  2.4190D 02  1.9460D 09  1.0000  1.4000
 31  4.0000D 01  0.0000D 00  1.2000D-01  1.0000D 08  2.5000D 08  2.1399D 68  2.1399D 68  2.4819D 02  1.9460D 09  1.0000  1.4000

TIMINGS AT CYCLE     1    TIME =   0.0000D 00
     PEZONE      TIMESTEP    CELL PRINT   LAYER PRNT    GRAPHICS     CHEMISTRY    DIFFUSION   CONDUCTION      ADINC
  0.0000D 00  5.1176D-04  0.0000D 00  0.0000D 00  0.0000D 00  0.0000D 00  0.0000D 00  0.0000D 00  0.0000D 00

ADINC FREQUENCY COUNTERS (SINCE LAST CHECK) AT CYCLE     1
        NO. CALLS =     0    NO. TIMESTEPS =     0    TOTAL NO. ITERATIONS =     0

  LAYER BOUNDARY       INTER 1          INTER 2          INTER 3          INTER 4          INTER 5          INTER 6
INTERFACE POSITION  1.00000000D-20  1.00000000D 01  1.50000000D 01  3.00000000D 01  3.50000000D 01  4.00000000D 01
INTERFACE VELOCITY  0.00000000D 00  0.00000000D 00  0.00000000D 00  0.00000000D 00  0.00000000D 00  0.00000000D 00
INTERFACE AREA      6.28318531D-20  6.28318531D 01  9.42477796D 01  1.88495559D 02  2.19911486D 02  2.51327412D 02

                    TOTALS          SHELL 1         SHELL 2         SHELL 3         SHELL 4         SHELL 5
THERMAL ERG   2.953882226D 11  4.712153337D 08  3.926990820 08  1.413712100-01  6.806761970-02  2.945243110 11
KINETIC ERG   0.000000000 00  0.000000000 00  0.000000000 00  0.000000000 00  0.000000000 00  0.000000000 00
 TOTAL  ERG   2.953882226D 11  4.712153337D 08  3.926990820 08  1.413712100-01  6.806761970-02  2.945243110 11
VOL AVG RHO   2.03454375D 00  1.20000000D-03  1.20000000D-03  1.00000000D 00  7.80000000D 00  1.20000000D-01
VOL AVG PRE   2.42031250D 07  1.00000000D 06  1.00000000D 06  1.00000000D 06  1.00000000D 06  1.00000000D 06
VOL AVG GAM   9.01043750D-01  1.66670000D 00  2.00000000D 00  5.00000000D-01  5.00000000D-01  1.40000000D 00
VOL AVG ENT   1.08783420D 11  7.38122794D 10  6.94444440D 11  1.00000107D 11  3.5P057422D 10  1.94601532D 09
VOL AVG RHOC  2.00625000D 00  0.00000000D 00  0.00000000D 00  1.00000000D 00  7.80000000D 00  0.00000000D 00
LAYER VOLUME  5.02654825D 03  3.14159265D 02  3.92699082D 02  2.12057504D 03  1.02101761D 03  1.17809725D 03
LAYER MASS    1.02267323D 04  3.76991118D-01  4.71238898D-01  2.12057504D 03  7.96393738D 03  1.41371669D 02
```

AFTER STEP NO. 100 DT = 0.45894521D-05 THE TIME IS 0.76786384D-03

I	POSITION	VELOCITY	DENSITY	PRESSURE	ENERGY	AVG PRESS	AVG VELOC	CELL VOLUME	ENTROPY	THFRAC	GAMMA
1	1.0000D-20	0.0000D 00	2.1399D 68	2.1399D 68	2.1399D 68	2.1399D 68	0.0000D 00	2.1399D 68	2.1399D 68	**********	**********
2	3.0938D 00	-3.6085D 02	1.3936D-03	1.2822D 06	1.9232D 06	1.2811D 06	-3.5645D 02	3.0071D 01	7.3812D 10	1.0000	1.6667
3	6.1738D 00	-1.0374D 03	1.4013D-03	1.2950D 06	1.9430D 06	1.2933D 06	-1.0378D 03	8.9675D 01	7.3812D 10	0.9997	1.6667
4	9.2574D 00	-1.8192D 03	1.4111D-03	1.2946D 06	1.9435D 06	1.2926D 06	-1.8184D 03	1.4949D 02	7.3812D 10	0.9991	1.6667
5	1.1624D 01	-2.2139D 03	1.3662D-03	1.2961D 06	1.2990D 06	1.2942D 06	-2.2084D 03	1.5522D 02	6.9444D 11	0.9978	2.0000
6	1.3975D 01	-2.6731D 03	1.3708D-03	1.3050D 06	1.3092D 06	1.3029D 06	-2.6658D 03	1.8907D 02	6.9444D 11	0.9968	2.0000
7	1.4046D 01	-2.6595D 03	1.0000D 00	1.4371D 06	3.5545D 06	1.4350D 06	-2.6522D 03	6.2971D 00	1.0000D 11	0.0000	0.5000
8	1.4260D 01	-2.6195D 03	1.0000D 00	1.9357D 06	3.4831D 06	1.9333D 06	-2.6124D 03	1.9059D 01	1.0000D 11	0.0000	0.5000
9	1.4617D 01	-2.5557D 03	1.0000D 00	2.9121D 06	3.3468D 06	2.9091D 06	-2.5488D 03	3.2323D 01	1.0000D 11	0.0000	0.5000
10	1.5114D 01	-2.4716D 03	1.0000D 00	4.3274D 06	3.1575D 06	4.3238D 06	-2.4650D 03	4.6426D 01	1.0000D 11	0.0000	0.5000
11	1.5750D 01	-2.3718D 03	1.0000D 00	6.1302D 06	2.9299D 06	6.1259D 06	-2.3655D 03	6.1701D 01	1.0000D 11	0.0000	0.5000
12	1.6524D 01	-2.2607D 03	1.0000D 00	8.2623D 06	2.6794D 06	8.2575D 06	-2.2548D 03	7.8484D 01	1.0000D 11	0.0000	0.5000
13	1.7434D 01	-2.1427D 03	1.0000D 00	1.0664D 07	2.4202D 06	1.0659D 07	-2.1371D 03	9.7119D 01	1.0000D 11	0.0000	0.5000
14	1.8480D 01	-2.0215D 03	1.0000D 00	1.3279D 07	2.1639D 06	1.3274D 07	-2.0163D 03	1.1791D 02	1.0000D 11	0.0000	0.5000
15	1.9658D 01	-1.9033D 03	1.0000D 00	1.6055D 07	1.9180D 06	1.6050D 07	-1.8955D 03	1.4123D 02	1.0000D 11	0.0000	0.5000
16	2.0970D 01	-1.7814D 03	1.0000D 00	1.8949D 07	1.6999D 06	1.8944D 07	-1.7770D 03	1.6740D 02	1.0000D 11	0.0000	0.5000
17	2.2413D 01	-1.6667D 03	1.0000D 00	2.1922D 07	1.4829D 06	2.1919D 07	-1.6625D 03	1.9675D 02	1.0000D 11	0.0000	0.5000
18	2.3989D 01	-1.5573D 03	1.0000D 00	2.4944D 07	1.2963D 06	2.4942D 07	-1.5534D 03	2.2962D 02	1.0000D 11	0.0000	0.5000
19	2.5695D 01	-1.4539D 03	1.0000D 00	2.7994D 07	1.1307D 06	2.7990D 07	-1.4503D 03	2.6634D 02	1.0000D 11	0.0000	0.5000
20	2.7532D 01	-1.3568D 03	1.0000D 00	3.1041D 07	9.8516D 05	3.1042D 07	-1.3535D 03	3.0725D 02	1.0000D 11	0.0000	0.5000
21	2.9501D 01	-1.2663D 03	1.0000D 00	3.4080D 07	8.5807D 05	3.4084D 07	-1.2632D 03	3.5268D 02	1.0000D 11	0.0000	0.5000
22	2.9955D 01	-1.2471D 03	7.8000D 00	3.8203D 07	6.1585D 06	3.8209D 07	-1.2441D 03	8.4926D 01	3.5806D 10	0.0000	0.5000
23	3.0786D 01	-1.2134D 03	7.8000D 00	4.5478D 07	5.9007D 06	4.5490D 07	-1.2105D 03	1.5853D 02	3.5806D 10	0.0000	0.5000
24	3.1861D 01	-1.1725D 03	7.8000D 00	5.5977D 07	5.5472D 06	5.5997D 07	-1.1697D 03	2.1153D 02	3.5806D 10	0.0000	0.5000
25	3.3132D 01	-1.1275D 03	7.8000D 00	6.8452D 07	5.1539D 06	6.8482D 07	-1.1248D 03	2.5961D 02	3.5806D 10	0.0000	0.5000
26	3.4573D 01	-1.0805D 03	7.8000D 00	8.2295D 07	4.7493D 06	8.2336D 07	-1.0779D 03	3.0642D 02	3.5806D 10	0.0000	0.5000
27	3.5667D 01	-8.5143D 02	1.1692D-01	8.9564D 07	2.2396D 08	8.9612D 07	-8.4832D 02	2.4132D 02	1.9460D 09	0.9998	1.4000
28	3.6756D 01	-6.2745D 02	1.1108D-01	8.9705D 07	2.2439D 08	8.9793D 07	-6.2466D 02	2.4776D 02	1.9460D 09	0.9999	1.4000
29	3.7840D 01	-4.0628D 02	1.1122D-01	8.9906D 07	2.2478D 08	8.9956D 07	-4.0416D 02	2.5422D 02	1.9460D 09	0.9999	1.4000
30	3.8922D 01	-1.9590D 02	1.1133D-01	9.0030D 07	2.2508D 08	9.0079D 07	-1.9476D 02	2.6075D 02	1.9460D 09	1.0000	1.4000
31	4.0000D 01	0.0000D 00	1.1139D-01	9.0098D 07	2.2525D 08	9.0145D 07	0.0000D 00	2.6738D 02	1.9460D 09	1.0000	1.4000

TIMINGS AT CYCLE 101 TIME = 7.6786D-04

REZONE	TIMESTEP	CELL PRINT	LAYER PRNT	GRAPHICS	CHEMISTRY	DIFFUSION	CONDUCTION	ADINC
0.0000D 00	5.1666D-02	1.2959D-01	3.1420D-02	0.0000D 00	0.0000D 00	0.0000D 00	0.0000D 00	1.1407D 00

ADINC FREQUENCY COUNTERS (SINCE LAST CHECK) AT CYCLE 101
NO. CALLS = 100 NO. TIMESTEPS = 50 TOTAL NO. ITERATIONS = 150

LAYER BOUNDARY	INTER 1	INTER 2	INTER 3	INTER 4	INTER 5	INTER 6
INTERFACE POSITION	1.0000000D-20	9.2573997D 00	1.3974616D 01	2.9500675D 01	3.4572962D 01	4.0000000D 01
INTERFACE VELOCITY	0.0000000D 00	-1.8191639D 03	-2.6731178D 03	-1.2663113D 03	-1.0805297D 03	0.0000000D 00
INTERFACE AREA	6.2831853D-20	5.8165958D 01	8.7805102D 01	1.8535821D 02	2.1722832D 02	2.5132741D 02

	TOTALS	SHELL 1	SHELL 2	SHELL 3	SHELL 4	SHELL 5
THERMAL ERG	2.8664785D 11	5.2228047D 08	4.4791795D 08	2.4537246D 03	2.0719691D 04	2.8567763D 11
KINETIC ERG	8.7272835D 09	3.1911158D 05	1.2501372D 06	3.2747107D 09	5.4251129D 09	2.5890603D 07
TOTAL ERG	2.9537514D 11	5.2259958D 08	4.4916809D 08	3.2747131D 09	5.4251337D 09	2.8570352D 11
VOL AVG RHO	2.0345437D 00	1.4002423D-03	1.3687324D-03	1.0000000D 00	7.8000033D 00	1.1119065D-01
VOL AVG PRE	4.5520269D 07	1.2933210D 06	1.3009956D 06	2.2852422D 07	8.3938574D 07	8.9875665D 07
VOL AVG GAM	8.9288154D-01	1.6667000D 00	2.0000000D 00	5.0000000D-01	5.0000000D-01	1.4000000D 00
VOL AVG ENT	1.0147165D 11	7.3812279D 10	6.9444444D 11	1.0000010D 11	3.5805742D 10	1.9460153D 09
VOL AVG RHOC	2.0062929D 00	0.0000000D 00	0.0000000D 00	1.0000000D 00	7.8000000D 00	0.0000000D 00
LAYER VOLUME	5.0265482D 03	2.6923276D 02	3.4428853D 02	2.1205749D 03	1.0210171D 03	1.2714349D 03
LAYER MASS	1.0226732D 04	3.7699118D-01	4.7123889D-01	2.1205750D 03	7.9639374D 03	1.4137166D 02

AFTER STEP NO. 200 DT = 0.33154652D-05 THE TIME IS 0.11507458D-02

I	POSITION	VELOCITY	DENSITY	PRESSURE	ENERGY	AVG PRESS	AVG VELOC	CELL VOLUME	ENTROPY	THFRAC	GAMMA
1	1.0000D-20	0.0000D 00	2.1399D 68	2.1399D 68	2.1399D 68	2.1399D 68	0.0000D 00	2.1399D 68	2.1399D 68	**********	**********
2	2.7740D 00	-1.2096D 03	1.7327D-03	1.8446D 06	2.7680D 06	1.8406D 06	-1.2081D 03	2.4175D 01	7.3812D 10	0.9995	1.6667
3	5.5441D 00	-2.1973D 03	1.7360D-03	1.8505D 06	2.7790D 06	1.8469D 06	-2.1960D 03	7.2387D 01	7.3812D 10	0.9988	1.6667
4	8.3119D 00	-3.1706D 03	1.7384D-03	1.8547D 06	2.7890D 06	1.8513D 06	-3.1725D 03	1.2048D 02	7.3812D 10	0.9974	1.6667
5	1.0510D 01	-3.5895D 03	1.6316D-03	1.8487D 06	1.8582D 06	1.8457D 06	-3.5873D 03	1.2997D 02	6.9444D 11	0.9949	2.0000
6	1.2686D 01	-4.0738D 03	1.6340D-03	1.8542D 06	1.8664D 06	1.8511D 06	-4.0680D 03	1.5862D 02	6.9444D 11	0.9934	2.0000
7	1.2765D 01	-4.0486D 03	1.0000D 00	2.0127D 06	8.2465D 06	2.0095D 06	-4.0429D 03	6.2971D 00	1.0000D 11	0.0000	0.5000
8	1.3001D 01	-3.9753D 03	1.0000D 00	2.6076D 06	8.0466D 06	2.6037D 06	-3.9698D 03	1.9059D 01	1.0000D 11	0.0000	0.5000
9	1.3391D 01	-3.8596D 03	1.0000D 00	3.7562D 06	7.6699D 06	3.7513D 06	-3.8543D 03	3.2323D 01	1.0000D 11	0.0000	0.5000
10	1.3931D 01	-3.7098D 03	1.0000D 00	5.3855D 06	7.1563D 06	5.3793D 06	-3.7046D 03	4.6426D 01	1.0000D 11	0.0000	0.5000
11	1.4619D 01	-3.5352D 03	1.0000D 00	7.4045D 06	6.5536D 06	7.3968D 06	-3.5306D 03	6.1701D 01	1.0000D 11	0.0000	0.5000
12	1.5450D 01	-3.3451D 03	1.0000D 00	9.7185D 06	5.9084D 06	9.7096D 06	-3.3409D 03	7.8484D 01	1.0000D 11	0.0000	0.5000
13	1.6420D 01	-3.1476D 03	1.0000D 00	1.2240D 07	5.2596D 06	1.2230D 07	-3.1437D 03	9.7110D 01	1.0000D 11	0.0000	0.5000
14	1.7526D 01	-2.9490D 03	1.0000D 00	1.4896D 07	4.6361D 06	1.4886D 07	-2.9455D 03	1.1791D 02	1.0000D 11	0.0000	0.5000
15	1.8765D 01	-2.7543D 03	1.0000D 00	1.7627D 07	4.0565D 06	1.7616D 07	-2.7511D 03	1.4123D 02	1.0000D 11	0.0000	0.5000
16	2.0134D 01	-2.5669D 03	1.0000D 00	2.0389D 07	3.5307D 06	2.0379D 07	-2.5640D 03	1.6740D 02	1.0000D 11	0.0000	0.5000
17	2.1634D 01	-2.3890D 03	1.0000D 00	2.3150D 07	3.0623D 06	2.3141D 07	-2.3864D 03	1.9675D 02	1.0000D 11	0.0000	0.5000
18	2.3262D 01	-2.2218D 03	1.0000D 00	2.5889D 07	2.6505D 06	2.5881D 07	-2.2194D 03	2.2962D 02	1.0000D 11	0.0000	0.5000
19	2.5018D 01	-2.0659D 03	1.0000D 00	2.8589D 07	2.2920D 06	2.8583D 07	-2.0637D 03	2.6634D 02	1.0000D 11	0.0000	0.5000
20	2.6901D 01	-1.9212D 03	1.0000D 00	3.1242D 07	1.9819D 06	3.1238D 07	-1.9192D 03	3.0725D 02	1.0000D 11	0.0000	0.5000
21	2.8913D 01	-1.7876D 03	1.0000D 00	3.3841D 07	1.7150D 06	3.3838D 07	-1.7858D 03	3.5268D 02	1.0000D 11	0.0000	0.5000
22	2.9377D 01	-1.7594D 03	7.8000D 00	3.7317D 07	1.2265D 07	3.7318D 07	-1.7576D 03	8.4926D 01	3.5806D 10	0.0000	0.5000
23	3.0223D 01	-1.7101D 03	7.8000D 00	4.3427D 07	1.1731D 07	4.3432D 07	-1.7083D 03	1.5853D 02	3.5806D 10	0.0000	0.5000
24	3.1317D 01	-1.6503D 03	7.8000D 00	5.2201D 07	1.1003D 07	5.2213D 07	-1.6487D 03	2.1153D 02	3.5806D 10	0.0000	0.5000
25	3.2610D 01	-1.5849D 03	7.8000D 00	6.2566D 07	1.0197D 07	6.2587D 07	-1.5833D 03	2.5961D 02	3.5806D 10	0.0000	0.5000
26	3.4073D 01	-1.5169D 03	7.8000D 00	7.3994D 07	9.3717D 06	7.4026D 07	-1.5154D 03	3.0642D 02	3.5806D 10	0.0000	0.5000
27	3.5274D 01	-1.2027D 03	1.0229D-01	7.9966D 07	2.0001D 08	8.0004D 07	-1.2011D 03	2.6167D 02	1.9460D 09	0.9995	1.4000
28	3.6466D 01	-8.9409D 02	1.0240D-01	8.0090D 07	2.0028D 08	8.0129D 07	-8.9263D 02	2.6875D 02	1.9460D 09	0.9997	1.4000
29	3.7651D 01	-5.8702D 02	1.0251D-01	8.0207D 07	2.0055D 08	8.0247D 07	-5.8584D 02	2.7582D 02	1.9460D 09	0.9999	1.4000
30	3.8828D 01	-2.8625D 02	1.0260D-01	8.0302D 07	2.0077D 08	8.0343D 07	-2.8555D 02	2.8294D 02	1.9460D 09	0.9999	1.4000
31	4.0000D 01	0.0000D 00	1.0265D-01	8.0359D 07	2.0090D 08	8.0399D 07	0.0000D 00	2.9014D 02	1.9460D 09	1.0000	1.4000

TIMINGS AT CYCLE 201 TIME = 1.1507D-03

REZONE	TIMESTEP	CELL PRNT	LAYER PRNT	GRAPHICS	CHEMISTRY	DIFFUSION	CONDUCTION	ADINC
0.0000D 00	1.0282D-01	2.5942D-01	6.3069D-02	0.0000D 00	0.0000D 00	0.0000D 00	0.0000D 00	2.2802D 00

ADINC FREQUENCY COUNTERS (SINCE LAST CHECK) AT CYCLE 201
NO. CALLS = 200 NO. TIMESTEPS = 50 TOTAL NO. ITERATIONS = 150

LAYER BOUNDARY	INTER 1	INTER 2	INTER 3	INTER 4	INTER 5	INTER 6
INTERFACE POSITION	1.0000000D-20	8.3118696D 00	1.2686490D 01	2.6912748D 01	3.4072670D 01	0.0000000D 01
INTERFACE VELOCITY	0.0000000D 00	-3.1706331D 03	-4.0737677D 03	-1.7875880D 03	-1.5168816D 03	0.0000000D 00
INTERFACE AREA	6.2831853D-20	5.2225017D 01	7.9711571D 01	1.8166415D 02	2.1468490D 02	2.5132741D 02

	TOTALS	SHELL 1	SHELL 2	SHELL 3	SHELL 4	SHELL 5
THERMAL ERG	2.77657661D 11	6.029668200 08	5.34372771D 08	2.57016952D 03	1.5680552[illegible] 04	2.7652[illegible]3D 11
KINETIC ERG	1.77142160D 10	1.13918221D 06	3.18612003D 06	6.91020647D 09	1.07477[illegible] 10	5.19240525D 07
TOTAL ERG	2.95371877D 11	6.041060020 08	5.37558891D 08	6.91022954D 09	1.07477588 10	2.76572227D 11
VOL AVG RHO	2.03454375D 00	1.73693593D-03	1.63292203D-03	1.00000006D 00	7.8[illegible] 00	1.02493294D-01
VOL AVG PRE	4.41068059D 07	1.85215168D 06	1.85169151D 06	2.36486051D 07	5.877653671 07	8.01899751D 07
VOL AVG GAM	8.83463599D-01	1.6667[illegible]D 00	2.00000000D 00	5.00[illegible]D-01	5.00[illegible]D-01	1.40000000D 00
VOL AVG ENT	9.30514939D 10	7.36122794D 10	6.94444444D 11	1.00000107D 11	3.58[illegible] 10	1.94601532D 09
VOL AVG RHOC	2.00624940D 00	0.00[illegible]D 00	0.00000[illegible] 00	1.00[illegible] 00	7.8[illegible] 00	0.00000000D 00
LAYER VOLUME	5.02654825D 03	2.17043768D 02	2.88582831[illegible] 02	2.12057491D 03	1.02[illegible] 03	1.37932604D 03
LAYER MASS	1.02267323[illegible] 04	3.76991118D-01	4.71238898D-01	2.12057504D 03	7.96[illegible] 03	1.41371669D 02

AFTER STEP NO. 300 DT = 0.28457412D-05 THE TIME IS 0.14559941D-02

I	POSITION	VELOCITY	DENSITY	PRESSURE	ENERGY	AVG PRESS	AVG VELOC	CELL VOLUME	ENTROPY	THFRAC	GAMMA
1	1.0000D-20	0.0000D 00	2.1399D 68	2.1399D 68	2.1399D 68	2.1399D 68	0.0000D 00	2.1399D 68	2.1399D 68	**********	**********
2	2.4571D 00	-1.3764D 03	2.2084D-03	2.7638D 06	4.1475D 06	2.7572D 06	-1.3654D 03	1.8968D 01	7.3812D 10	0.9995	1.6667
3	4.8898D 00	-2.6872D 03	2.2380D-03	2.8258D 06	4.2450D 06	2.8193D 06	-2.6776D 03	5.6150D 01	7.3812D 10	0.9985	1.6667
4	7.3083D 00	-3.8642D 03	2.2598D-03	2.8718D 06	4.3213D 06	2.8655D 06	-3.8569D 03	9.2681D 01	7.3812D 10	0.9968	1.6667
5	9.2972D 00	-4.5272D 03	2.0438D-03	2.9008D 06	2.9194D 06	2.8946D 06	-4.5208D 03	1.0376D 02	6.9444D 11	0.9936	2.0000
6	1.1254D 01	-5.3457D 03	2.0512D-03	2.9217D 06	2.9475D 06	2.9150D 06	-5.3398D 03	1.2636D 02	6.9444D 11	0.9913	2.0000
7	1.1343D 01	-5.3039D 03	1.0000D 00	3.1345D 06	1.4176D 07	3.1274D 06	-5.2981D 03	6.2971D 00	1.0000D 11	0.0000	0.5000
8	1.1607D 01	-5.1831D 03	1.0000D 00	3.9249D 06	1.3744D 07	3.9166D 06	-5.1776D 03	1.9059D 01	1.0000D 11	0.0000	0.5000
9	1.2042D 01	-4.9959D 03	1.0000D 00	5.4182D 06	1.2943D 07	5.4078D 06	-4.9908D 03	3.2323D 01	1.0000D 11	0.0000	0.5000
10	1.2641D 01	-4.7593D 03	1.0000D 00	7.4661D 06	1.1882D 07	7.4531D 06	-4.7547D 03	4.6426D 01	1.0000D 11	0.0000	0.5000
11	1.3395D 01	-4.4914D 03	1.0000D 00	9.8990D 06	1.0679D 07	9.8836D 06	-4.4872D 03	6.1791D 01	1.0000D 11	0.0000	0.5000
12	1.4298D 01	-4.2080D 03	1.0000D 00	1.2560D 07	9.4398D 06	1.2542D 07	-4.2043D 03	7.8484D 01	1.0000D 11	0.0000	0.5000
13	1.5340D 01	-3.9219D 03	1.0000D 00	1.5323D 07	8.2415D 06	1.5304D 07	-3.9187D 03	9.7110D 01	1.0000D 11	0.0000	0.5000
14	1.6519D 01	-3.6422D 03	1.0000D 00	1.8097D 07	7.1325D 06	1.8078D 07	-3.6394D 03	1.1791D 02	1.0000D 11	0.0000	0.5000
15	1.7827D 01	-3.3748D 03	1.0000D 00	2.0825D 07	6.1370D 06	2.0806D 07	-3.3724D 03	1.4123D 02	1.0000D 11	0.0000	0.5000
16	1.9264D 01	-3.1232D 03	1.0000D 00	2.3472D 07	5.2622D 06	2.3454D 07	-3.1210D 03	1.6740D 02	1.0000D 11	0.0000	0.5000
17	2.0826D 01	-2.8889D 03	1.0000D 00	2.6022D 07	4.5045D 06	2.6005D 07	-2.8870D 03	1.9675D 02	1.0000D 11	0.0000	0.5000
18	2.2513D 01	-2.6725D 03	1.0000D 00	2.8469D 07	3.8545D 06	2.8452D 07	-2.6708D 03	2.2962D 02	1.0000D 11	0.0000	0.5000
19	2.4323D 01	-2.4736D 03	1.0000D 00	3.0812D 07	3.3005D 06	3.0797D 07	-2.4721D 03	2.6634D 02	1.0000D 11	0.0000	0.5000
20	2.6256D 01	-2.2915D 03	1.0000D 00	3.3056D 07	2.8300D 06	3.3043D 07	-2.2901D 03	3.0725D 02	1.0000D 11	0.0000	0.5000
21	2.8314D 01	-2.1250D 03	1.0000D 00	3.5206D 07	2.4312D 06	3.5195D 07	-2.1237D 03	3.5268D 02	1.0000D 11	0.0000	0.5000
22	2.8787D 01	-2.0900D 03	7.8000D 00	3.8029D 07	1.7320D 07	3.8022D 07	-2.0888D 03	8.4926D 01	3.5806D 10	0.0000	0.5000
23	2.9651D 01	-2.0292D 03	7.8000D 00	4.2966D 07	1.6536D 07	4.2964D 07	-2.0280D 03	1.5853D 02	3.5806D 10	0.0000	0.5000
24	3.0765D 01	-1.9557D 03	7.8000D 00	5.0011D 07	1.5471D 07	5.0018D 07	-1.9545D 03	2.1153D 02	3.5806D 10	0.0000	0.5000
25	3.2080D 01	-1.8755D 03	7.8000D 00	5.8269D 07	1.4298D 07	5.8286D 07	-1.8744D 03	2.5961D 02	3.5806D 10	0.0000	0.5000
26	3.3566D 01	-1.7925D 03	7.8000D 00	6.7302D 07	1.3104D 07	6.7330D 07	-1.7915D 03	3.0642D 02	3.5806D 10	0.0000	0.5000
27	3.4878D 01	-1.3843D 03	9.4892D-02	7.1989D 07	1.8009D 08	7.2024D 07	-1.3832D 03	2.8207D 02	1.9460D 09	0.9993	1.4000
28	3.6175D 01	-1.0076D 03	9.4996D-02	7.2100D 07	1.8032D 08	7.2133D 07	-1.0066D 03	2.8970D 02	1.9460D 09	0.9996	1.4000
29	3.7461D 01	-6.5544D 02	9.5089D-02	7.2198D 07	1.8053D 08	7.2231D 07	-6.5469D 02	2.9735D 02	1.9460D 09	0.9998	1.4000
30	3.8735D 01	-3.2101D 02	9.5156D-02	7.2270D 07	1.8069D 08	7.2302D 07	-3.2066D 02	3.0506D 02	1.9460D 09	0.9999	1.4000
31	4.0000D 01	0.0000D 00	9.5192D-02	7.2308D 07	1.8077D 08	7.2341D 07	0.0000D 00	3.1287D 02	1.9460D 09	1.0000	1.4000

TIMINGS AT CYCLE 301 TIME = 1.4560D-03

REZONE	TIMESTEP	CELL PRINT	LAYER PRNT	GRAPHICS	CHEMISTRY	DIFFUSION	CONDUCTION	ADINC
0.0000D 00	1.5396D-01	3.8903D-01	9.4835D-02	0.0000D 00	0.0000D 00	0.0000D 00	0.0000D 00	3.4215D 00

ADINC FREQUENCY COUNTERS (SINCE LAST CHECK) AT CYCLE 301
NO. CALLS = 300 NO. TIMESTEPS = 50 TOTAL NO. ITERATIONS = 150

LAYER BOUNDARY	INTER 1	INTER 2	INTER 3	INTER 4	INTER 5	INTER 6
INTERFACE POSITION	1.0000000D-20	7.3083459OD 00	1.1254309 1D 01	2.8313590BD 01	3.3565746 2D 01	4.0000000D 01
INTERFACE VELOCITY	0.0000000D 00	-3.86421312D 03	-5.34571484D 03	-2.1249B014D 03	-1.7024F162D 03	0.0000000D 00
INTERFACE AREA	6.28318531D-20	4.59196916D 01	7.07129097D 01	1.7789953BD 02	2.1088980 4D 02	2.5132741 2D 02

	TOTALS	SHELL 1	SHELL 2	SHELL 3	SHELL 4	SHELL 5
THERMAL ERG	2.697129590 11	7.15841227D 08	6.70159462D 08	3.184812000 03	1.25651369D 04	2.683269430 11
KINETIC ERG	2.56553254D 10	1.68455012D 06	5.18509881D 06	1.048722160 10	1.50925018D 10	6.873236270 07
TOTAL ERG	2.95368285D 11	7.17525777D 08	6.75344561D 08	1.048722480 10	1.50925144D 10	2.683956760 11
VOL AVG RHO	2.03454375D 00	2.24668951D-03	2.04784996D-03	1.000000070 00	7.80090248D 00	9.50689472D-02
VOL AVG PRE	4.37653938D 07	2.84419325D 06	2.91229360D 06	2.600274480 07	5.52095529D 07	7.217729000 07
VOL AVG GAM	8.73871018D-01	1.66670000D 00	2.00000000D 00	5.000000000-01	5.00000000D-01	1.400000000 00
VOL AVG ENT	8.42917939D 10	7.38122704D 10	6.94444444D 11	1.000001070 11	3.58057422D 10	1.946015320 09
VOL AVG RHOC	2.00624947D 00	0.00000000D 00	0.00000000D 00	1.000000000 00	7.80000000D 00	0.000000000 00
LAYER VOLUME	5.02654825D 03	1.67798495D 02	2.30113977D 02	2.120574880 03	1.02101729D 03	1.487043600 03
LAYER MASS	1.02267323D 04	3.76991118D-01	4.71238898D-01	2.120575040 03	7.96303738D 03	1.413716690 02

AFTER STEP NO. 400 DT = 0.26215522D-05 THE TIME IS 0.17281316D-02

I	POSITION	VELOCITY	DENSITY	PRESSURE	ENERGY	AVG PRESS	AVG VELOC	CELL VOLUME	ENTROPY	THERAC	GAMMA
1	1.0000D-20	0.0000D 00	2.1399D 68	2.1399D 68	2.1399D 68	2.1399D 68	0.0000D 00	2.1399D 68	2.1300D 68	**********	**********
2	2.0436D 00	-1.4834D 03	3.1925D-03	5.1082D 06	7.6654D 06	5.0936D 06	-1.4855D 03	1.3121D 01	7.3812D 10	0.9995	1.6667
3	4.0902D 00	-2.8256D 03	3.1865D-03	5.0922D 06	7.6482D 06	5.0787D 06	-2.8184D 03	3.9436D 01	7.3812D 10	0.9986	1.6667
4	6.1273D 00	-4.4376D 03	3.2030D-03	5.1362D 06	7.7288D 06	5.1211D 06	-4.4316D 03	6.5389D 01	7.3812D 10	0.9968	1.6667
5	7.8922D 00	-5.5563D 03	2.7280D-03	5.1680D 06	5.2039D 06	5.1516D 06	-5.5476D 03	7.7734D 01	6.9444D 11	0.9931	2.0000
6	9.6136D 00	-6.7834D 03	2.7376D-03	5.2047D 06	5.2588D 06	5.1873D 06	-6.7760D 03	9.4673D 01	6.9444D 11	0.9897	2.0000
7	9.7173D 00	-6.7119D 03	1.0000D 00	5.5413D 06	2.2761D 07	5.5231D 06	-6.7039D 03	6.2971D 00	1.0000D 11	0.0000	0.5000
8	1.0025D 01	-6.5053D 03	1.0000D 00	6.7714D 06	2.1823D 07	6.7502D 06	-6.4987D 03	1.9059D 01	1.0000D 11	0.0000	0.5000
9	1.0525D 01	-6.1959D 03	1.0000D 00	9.0097D 06	2.0141D 07	8.9836D 06	-6.1901D 03	3.2323D 01	1.0000D 11	0.0000	0.5000
10	1.1205D 01	-5.8199D 03	1.0000D 00	1.1911D 07	1.8012D 07	1.1880D 07	-5.8149D 03	4.6426D 01	1.0000D 11	0.0000	0.5000
11	1.2050D 01	-5.4121D 03	1.0000D 00	1.5131D 07	1.5728D 07	1.5094D 07	-5.4079D 03	6.1701D 01	1.0000D 11	0.0000	0.5000
12	1.3045D 01	-4.9991D 03	1.0000D 00	1.8401D 07	1.3507D 07	1.8361D 07	-4.9956D 03	7.8484D 01	1.0000D 11	0.0000	0.5000
13	1.4181D 01	-4.5989D 03	1.0000D 00	2.1554D 07	1.1475D 07	2.1512D 07	-4.5966D 03	9.7110D 01	1.0000D 11	0.0000	0.5000
14	1.5448D 01	-4.2218D 03	1.0000D 00	2.4502D 07	9.6902D 06	2.4459D 07	-4.2194D 03	1.1791D 02	1.0000D 11	0.0000	0.5000
15	1.6840D 01	-3.8728D 03	1.0000D 00	2.7214D 07	8.1599D 06	2.7172D 07	-3.8708D 03	1.4123D 02	1.0000D 11	0.0000	0.5000
16	1.8354D 01	-3.5533D 03	1.0000D 00	2.9691D 07	6.8679D 06	2.9650D 07	-3.5516D 03	1.6740D 02	1.0000D 11	0.0000	0.5000
17	1.9987D 01	-3.2630D 03	1.0000D 00	3.1950D 07	5.7866D 06	3.1911D 07	-3.2615D 03	1.9675D 02	1.0000D 11	0.0000	0.5000
18	2.1739D 01	-3.0000D 03	1.0000D 00	3.4014D 07	4.8859D 06	3.3978D 07	-2.9988D 03	2.2962D 02	1.0000D 11	0.0000	0.5000
19	2.3608D 01	-2.7625D 03	1.0000D 00	3.5908D 07	4.1368D 06	3.5874D 07	-2.7614D 03	2.6634D 02	1.0000D 11	0.0000	0.5000
20	2.5596D 01	-2.5480D 03	1.0000D 00	3.7654D 07	3.5136D 06	3.7623D 07	-2.5470D 03	3.0725D 02	1.0000D 11	0.0000	0.5000
21	2.7702D 01	-2.3543D 03	1.0000D 00	3.9272D 07	2.9946D 06	3.9244D 07	-2.3534D 03	3.5268D 02	1.0000D 11	0.0000	0.5000
22	2.8186D 01	-2.3139D 03	7.8000D 00	4.1338D 07	2.1243D 07	4.1314D 07	-2.3130D 03	8.4926D 01	3.5806D 10	0.0000	0.5000
23	2.9067D 01	-2.2437D 03	7.8000D 00	4.4924D 07	2.0242D 07	4.4907D 07	-2.2429D 03	1.5853D 02	3.5806D 10	0.0000	0.5000
24	3.0203D 01	-2.1593D 03	7.8000D 00	4.9990D 07	1.8888D 07	4.9984D 07	-2.1586D 03	2.1153D 02	3.5806D 10	0.0000	0.5000
25	3.1542D 01	-2.0677D 03	7.8000D 00	5.5859D 07	1.7404D 07	5.5866D 07	-2.0670D 03	2.5961D 02	3.5806D 10	0.0000	0.5000
26	3.3052D 01	-1.9732D 03	7.8000D 00	6.2197D 07	1.5903D 07	6.2218D 07	-1.9726D 03	3.0642D 02	3.5806D 10	0.0000	0.5000
27	3.4475D 01	-1.5305D 03	8.8651D-02	6.5449D 07	1.6376D 08	6.5477D 07	-1.5303D 03	3.0193D 02	1.9460D 09	0.9992	1.4000
28	3.5879D 01	-1.1144D 03	8.8680D-02	6.5479D 07	1.6378D 08	6.5507D 07	-1.1144D 03	3.1033D 02	1.9460D 09	0.9995	1.4000
29	3.7267D 01	-7.2099D 02	8.8678D-02	6.5477D 07	1.6373D 08	6.5505D 07	-7.2125D 02	3.1884D 02	1.9460D 09	0.9998	1.4000
30	3.8640D 01	-3.5056D 02	8.8652D-02	6.5450D 07	1.6364D 08	6.5477D 07	-3.5085D 02	3.2744D 02	1.9460D 09	0.9999	1.4000
31	4.0000D 01	0.0000D 00	8.8623D-02	6.5420D 07	1.6355D 08	6.5448D 07	0.0000D 00	3.3606D 02	1.9460D 09	1.0000	1.4000

TIMINGS AT CYCLE 401 TIME = 1.7281D-03

REZONE	TIMESTEP	CELL PRINT	LAYER PRNT	GRAPHICS	CHEMISTRY	DIFFUSION	CONDUCTION	ADINC
0.0000D 00	2.0511D-01	5.1855D-01	1.2661D-01	0.0000D 00	0.0000D 00	0.0000D 00	0.0000D 00	4.5631D 00

ADINC FREQUENCY COUNTERS (SINCE LAST CHECK) AT CYCLE 401
NO. CALLS = 400 NO. TIMESTEPS = 50 TOTAL NO. ITERATIONS = 150

LAYER BOUNDARY	INTER 1	INTER 2	INTER 3	INTER 4	INTER 5	INTER 6
INTERFACE POSITION	1.00000000D-20	6.12725306D 00	9.61364676D 00	2.77023850D 01	3.30518084D 01	4.00000000D 01
INTERFACE VELOCITY	0.00000000D 00	-4.43759287D 03	-6.78337255D 03	-2.35425164D 03	-1.97322325D 03	0.00000000D 00
INTERFACE AREA	6.28318531D-20	3.84986664D 01	6.04043240D 01	1.74059218D 02	2.07670637D 02	2.51327412D 02

	TOTALS	SHELL 1	SHELL 2	SHELL 3	SHELL 4	SHELL 5
THERMAL ERG	2.62735111D 11	9.05483540D 08	8.94468931D 08	5.08631317D 03	1.10516451D 04	2.60935142D 11
KINETIC ERG	3.26275495D 10	2.08363397D 06	7.91819733D 06	1.41339703D 10	1.83999581D 10	8.36192314D 07
TOTAL ERG	2.95362660D 11	9.07567174D 08	9.02387129D 08	1.41339754D 10	1.83999692D 10	2.61018762D 11
VOL AVG RHO	2.03454375D 00	3.19631529D-03	1.73328725D-03	1.00000010D 00	7.80000228D 00	8.86563318D-02
VOL AVG PRE	4.51404140D 07	5.11834443D 06	5.18811274D 06	3.12468021D 07	5.36397126D 07	6.54545641D 07
VOL AVG GAM	8.64337695D-01	1.66670000D 00	2.00000000D 00	5.00000000D-01	5.00000000D-01	1.40000000D 00
VOL AVG ENT	7.56288952D 10	7.38122794D 10	6.94444444D 11	1.00000107D 11	3.58057422D 10	1.94601532D 09
VOL AVG RHOC	2.00624949D 00	0.00000000D 00	0.00000000D 00	1.00000000D 00	7.80000000D 00	0.00000000D 00
LAYER VOLUME	5.02654825D 03	1.17945536D 02	1.72407381D 02	2.12057482D 03	1.02101731D 03	1.59460319D 03
LAYER MASS	1.02267323D 04	3.76991118D-01	4.71238898D-01	2.12057504D 03	7.96393738D 03	1.41371670D 02

AFTER STEP NO. 500 DT = 0.25324248D-05 THE TIME IS 0.19848665D-02

I	POSITION	VELOCITY	DENSITY	PRESSURE	ENERGY	AVG PRESS	AVG VELOC	CELL VOLUME	ENTROPY	THFRAC	GAMMA
1	1.0000D-20	0.0000D 00	2.1399D 68	2.1399D 68	2.1399D 68	2.1399D 68	0.0000D 00	2.1399D 68	2.1399D 68	**********	**********
2	1.5677D 00	-1.6935D 03	5.2896D-03	1.1851D 07	1.7783D 07	1.1804D 07	-1.6794D 03	7.9190D 00	7.3812D 10	0.9996	1.6667
3	3.1667D 00	-3.6382D 03	5.3282D-03	1.1995D 07	1.8020D 07	1.1942D 07	-3.6216D 03	2.3585D 01	7.3812D 10	0.9984	1.6667
4	4.7387D 00	-5.7516D 03	5.3643D-03	1.2131D 07	1.8266D 07	1.2073D 07	-5.7464D 03	3.9043D 01	7.3812D 10	0.9962	1.6667
5	6.2114D 00	-7.2108D 03	4.1859D-03	1.2168D 07	1.2261D 07	1.2108D 07	-7.2057D 03	5.0660D 01	6.9444D 11	0.9924	2.0000
6	7.6332D 00	-8.8166D 03	4.1912D-03	1.2199D 07	1.2339D 07	1.2136D 07	-8.8048D 03	6.1839D 01	6.9444D 11	0.9886	2.0000
7	7.7633D 00	-8.6688D 03	1.0000D 00	1.2903D 07	3.8212D 07	1.2837D 07	-8.6575D 03	6.2971D 00	1.0000D 11	0.0000	0.5000
8	8.1447D 00	-8.2636D 03	1.0000D 00	1.5388D 07	3.5794D 07	1.5312D 07	-8.2532D 03	1.9059D 01	1.0000D 11	0.0000	0.5000
9	8.7536D 00	-7.6884D 03	1.0000D 00	1.9576D 07	3.1723D 07	1.9485D 07	-7.6805D 03	3.2323D 01	1.0000D 11	0.0000	0.5000
10	9.5605D 00	-7.0396D 03	1.0000D 00	2.4431D 07	2.7009D 07	2.4327D 07	-7.0335D 03	4.6426D 01	1.0000D 11	0.0000	0.5000
11	1.0538D 01	-6.3869D 03	1.0000D 00	2.9166D 07	2.2427D 07	2.9052D 07	-6.3823D 03	6.1701D 01	1.0000D 11	0.0000	0.5000
12	1.1663D 01	-5.7747D 03	1.0000D 00	3.3369D 07	1.8381D 07	3.3251D 07	-5.7673D 03	7.8484D 01	1.0000D 11	0.0000	0.5000
13	1.2920D 01	-5.2092D 03	1.0000D 00	3.6917D 07	1.4991D 07	3.6799D 07	-5.2067D 03	9.7110D 01	1.0000D 11	0.0000	0.5000
14	1.4299D 01	-4.7069D 03	1.0000D 00	3.9837D 07	1.2228D 07	3.9720D 07	-4.7050D 03	1.1791D 02	1.0000D 11	0.0000	0.5000
15	1.5793D 01	-4.2617D 03	1.0000D 00	4.2214D 07	1.0005D 07	4.2101D 07	-4.2603D 03	1.4123D 02	1.0000D 11	0.0000	0.5000
16	1.7399D 01	-3.8685D 03	1.0000D 00	4.4146D 07	8.2239D 06	4.4038D 07	-3.8674D 03	1.6749D 02	1.0000D 11	0.0000	0.5000
17	1.9114D 01	-3.5214D 03	1.0000D 00	4.5720D 07	6.7962D 06	4.5618D 07	-3.5205D 03	1.9675D 02	1.0000D 11	0.0000	0.5000
18	2.0939D 01	-3.2145D 03	1.0000D 00	4.7011D 07	5.6480D 06	4.6914D 07	-3.2138D 03	2.2962D 02	1.0000D 11	0.0000	0.5000
19	2.2874D 01	-2.9426D 03	1.0000D 00	4.8078D 07	4.7202D 06	4.7986D 07	-2.9421D 03	2.6634D 02	1.0000D 11	0.0000	0.5000
20	2.4920D 01	-2.7018D 03	1.0000D 00	4.8966D 07	3.9666D 06	4.8880D 07	-2.7005D 03	3.0725D 02	1.0000D 11	0.0000	0.5000
21	2.7079D 01	-2.4856D 03	1.0000D 00	4.9712D 07	3.3510D 06	4.9632D 07	-2.4853D 03	3.5268D 02	1.0000D 11	0.0000	0.5000
22	2.7573D 01	-2.4416D 03	7.8000D 00	5.0578D 07	2.3661D 07	5.0506D 07	-2.4407D 03	8.4926D 01	3.5806D 10	0.0000	0.5000
23	2.8474D 01	-2.3638D 03	7.8000D 00	5.2050D 07	2.2498D 07	5.1991D 07	-2.3636D 03	1.5853D 02	3.5806D 10	0.0000	0.5000
24	2.9633D 01	-2.2714D 03	7.8000D 00	5.4055D 07	2.0932D 07	5.4015D 07	-2.2712D 03	2.1153D 02	3.5806D 10	0.0000	0.5000
25	3.0996D 01	-2.1715D 03	7.8000D 00	5.6276D 07	1.9227D 07	5.6259D 07	-2.1713D 03	2.5961D 02	3.5806D 10	0.0000	0.5000
26	3.2531D 01	-2.0690D 03	7.8000D 00	5.8556D 07	1.7512D 07	5.8566D 07	-2.0688D 03	3.0642D 02	3.5806D 10	0.0000	0.5000
27	3.4073D 01	-1.9185D 03	8.2984D-02	5.9667D 07	1.4931D 08	5.9690D 07	-1.9181D 03	3.2255D 02	1.9460D 09	0.9990	1.4000
28	3.5587D 01	-1.1881E 03	8.3032D-02	5.9716D 07	1.4937D 08	5.9739D 07	-1.1877D 03	3.3144D 02	1.9460D 09	0.9994	1.4000
29	3.7078D 01	-7.7410D 02	8.3078D-02	5.9762D 07	1.4945D 08	5.9786D 07	-7.7383D 02	3.4034D 02	1.9460D 09	0.9997	1.4000
30	3.8548D 01	-3.7791D 02	8.3107D-02	5.9791D 07	1.4949D 08	5.9815D 07	-3.7776D 02	3.4929D 02	1.9460D 09	0.9999	1.4000
31	4.0000D 01	0.0000D 00	8.3123D-02	5.9807D 07	1.4952D 08	5.9832D 07	0.0000D 00	3.5829D 02	1.9460D 09	1.0000	1.4000

TIMINGS AT CYCLE 501 TIME = 1.9849D-03

REZONE	TIMESTEP	CELL PRINT	LAYER PRNT	GRAPHICS	CHEMISTRY	DIFFUSION	CONDUCTION	ADINC
0.0000D 00	2.5628D-01	6.4804E-01	1.5839D-01	0.0000D 00	0.0000D 00	0.0000E 00	0.0000D 00	5.7951D 00

ADINC FREQUENCY COUNTERS (SINCE LAST CHECK) AT CYCLE 501
NO. CALLS = 500 NO. TIMESTEPS = 50 TOTAL NO. ITERATIONS = 186

LAYER BOUNDARY	INTER 1	INTER 2	INTER 3	INTER 4	INTER 5	INTER 6
INTERFACE POSITION	1.00000000D-20	4.73874551D 00	7.63315800D 00	2.70788657D 01	3.25309832D 01	4.00000000D 01
INTERFACE VELOCITY	0.00000000D 00	-5.75156507D 03	-8.81656598D 03	-2.48561737D 03	-2.06904220D 03	0.00000000D 00
INTERFACE AREA	6.2831853 1D-20	2.97744162D 01	4.79605462D 01	1.70141531D 02	2.04398196D 02	2.51327412D 02

	TOTALS	SHELL 1	SHELL 2	SHELL 3	SHELL 4	SHELL 5
THERMAL ERG	2.56871742D 11	1.27554361D 09	1.37079693D 09	1.29648302D 04	1.16363032D 04	2.54225377D 11
KINETIC ERG	3.84795167D 10	3.45327636D 06	1.33730726D 07	1.80076467D 10	2.03614300D 10	9.36136772D 07
TOTAL ERG	2.95351259D 11	1.27899689D 09	1.38417000D 09	1.80076597D 10	2.03614416D 10	2.54318991D 11
VOL AVG RHO	2.03454375D 00	5.34385264D-03	4.18884521D-03	1.00000020D 00	7.80000240D 00	8.30664235D-02
VOL AVG PRE	5.04941225D 07	1.20544978D 07	1.21850216D 07	4.40286756D 07	5.53699707D 07	5.97505651D 07
VOL AVG GAM	8.54671740D-01	1.66670000D 00	2.00000000D 00	5.00000003D-01	5.00000000D-01	1.40000000D 00
VOL AVG ENT	6.66976791D 10	7.38122794D 10	6.94444444D 11	1.00000107D 11	3.58057422D 10	1.94601532D 09
VOL AVG RHOC	2.00624943D 00	0.00000000D 00	0.00000000D 00	1.00000000D 00	7.80000000D 00	0.00000000D 00
LAYER VOLUME	5.02654825D 03	7.95466906D 01	1.12498523D 02	2.12057462D 03	1.02101730D 03	1.70191111D 03
LAYER MASS	1.02267323D 04	3.76991118D-01	4.71238898D-01	2.12057504D 03	7.96393738D 03	1.41371669D 02

AFTER STEP NO. 600 DT = 0.26080601D-05 THE TIME IS 0.22397024D-02

I	POSITION	VELOCITY	DENSITY	PRESSURE	ENERGY	AVG PRESS	AVG VELOC	CELL VOLUME	ENTROPY	THERAC	GAMMA
1	1.0000D-20	0.0000D 00	2.1399D 68	2.1399D 68	2.1399D 68	2.1399D 68	0.0000D 00	2.1399D 68	2.1399D 68	**********	**********
2	9.6573D-01	-2.5847D 03	1.4296D-02	6.2151D 07	9.3270D 07	6.1514D 07	-2.5864D 03	2.0299D 00	7.3812D 10	0.9995	1.6667
3	1.9315D 00	-5.3159D 03	1.4296D-02	6.2149D 07	9.3381D 07	6.1482D 07	-5.3299D 03	8.7900D 00	7.3812D 10	0.9983	1.6667
4	2.8982D 00	-8.3134D 03	1.4278D-02	6.2017D 07	9.3412D 07	6.1308D 07	-8.3431D 03	1.4669D 01	7.3812D 10	0.9958	1.6667
5	3.9447D 00	-1.0675D 04	9.4264D-03	6.1706D 07	6.2161D 07	6.0991D 07	-1.0687D 04	2.2496D 01	6.5444D 11	0.9927	2.0000
6	4.9314D 00	-1.3099D 04	9.4195D-03	6.1616D 07	6.2311D 07	6.0893D 07	-1.3066D 04	2.7515D 01	6.5444D 11	0.9888	2.0000
7	5.1306D 00	-1.2591D 04	1.0000D 00	6.4547D 07	8.2437D 07	6.3796D 07	-1.2562D 04	6.2971D 00	1.0000D 11	0.0000	0.5000
8	5.6912D 00	-1.1352D 04	1.0000D 00	7.3689D 07	7.1274D 07	7.2853D 07	-1.1332D 04	1.9559D 01	1.0000D 11	0.0000	0.5000
9	6.5329D 00	-9.8898D 03	1.0000D 00	8.5499D 07	5.5867D 07	8.4665D 07	-9.8778D 03	3.2323D 01	1.0000D 11	0.0000	0.5000
10	7.5800D 00	-8.5241D 03	1.0000D 00	9.5082D 07	4.1919D 07	9.4167D 07	-8.5176D 03	4.6426D 01	1.0000D 11	0.0000	0.5000
11	8.7805D 00	-7.3590D 03	1.0000D 00	1.0126D 08	3.1195D 07	1.0036D 08	-7.3558D 03	6.1791D 01	1.0000D 11	0.0000	0.5000
12	1.0103D 01	-6.3956D 03	1.0000D 00	1.0461D 08	2.3417D 07	1.0375D 08	-6.3944D 03	7.8484D 01	1.0000D 11	0.0000	0.5000
13	1.1532D 01	-5.6634D 03	1.0000D 00	1.0599D 08	1.7840D 07	1.0518D 08	-5.6633D 03	9.7116D 01	1.0000D 11	0.0000	0.5000
14	1.3058D 01	-4.9485D 03	1.0000D 00	1.0608D 08	1.3811D 07	1.0530D 08	-4.9491D 03	1.1791D 02	1.0000D 11	0.0000	0.5000
15	1.4679D 01	-4.4022D 03	1.0000D 00	1.0532D 08	1.0855D 07	1.0459D 08	-4.4031D 03	1.4123D 02	1.0000D 11	0.0000	0.5000
16	1.6394D 01	-3.9418D 03	1.0000D 00	1.0403D 08	8.6499D 06	1.0334D 08	-3.9429D 03	1.6740D 02	1.0000D 11	0.0000	0.5000
17	1.8204D 01	-3.5499D 03	1.0000D 00	1.0240D 08	6.9774D 06	1.0175D 08	-3.5510D 03	1.9675D 02	1.0000D 11	0.0000	0.5000
18	2.0112D 01	-3.2132D 03	1.0000D 00	1.0055D 08	5.6892D 06	9.9935D 07	-3.2144D 03	2.2962D 02	1.0000D 11	0.0000	0.5000
19	2.2119D 01	-2.9216D 03	1.0000D 00	9.8566D 07	4.6834D 06	9.7986D 07	-2.9228D 03	2.6634D 02	1.0000D 11	0.0000	0.5000
20	2.4229D 01	-2.6672D 03	1.0000D 00	9.6504D 07	3.8883D 06	9.5956D 07	-2.6683D 03	3.0725D 02	1.0000D 11	0.0000	0.5000
21	2.6445D 01	-2.4438D 03	1.0000D 00	9.4400D 07	3.2529D 06	9.3883D 07	-2.4449D 03	3.5268D 02	1.0000D 11	0.0000	0.5000
22	2.6951D 01	-2.3979D 03	7.8000D 00	9.1492D 07	2.2852D 07	9.1017D 07	-2.3994D 03	8.4926D 01	3.5806D 10	0.0000	0.5000
23	2.7871D 01	-2.3187D 03	7.8000D 00	8.6383D 07	2.1678D 07	8.5980D 07	-2.3198D 03	1.5853D 02	3.5806D 10	0.0000	0.5000
24	2.9054D 01	-2.2243D 03	7.8000D 00	7.8969D 07	2.0106D 07	7.8668D 07	-2.2253D 03	2.1153D 02	3.5806D 10	0.0000	0.5000
25	3.0443D 01	-2.1228D 03	7.8000D 00	7.0115D 07	1.8405D 07	6.9935D 07	-2.1238D 03	2.5941D 02	3.5806D 10	0.0000	0.5000
26	3.2005D 01	-2.0192D 03	7.8000D 00	6.0246D 07	1.6707D 07	6.0197D 07	-2.0202D 03	3.0642D 02	3.5806D 10	0.0000	0.5000
27	3.3662D 01	-1.9663D 03	7.8299D-02	5.5005D 07	1.3764D 08	5.5025D 07	-1.9675D 03	3.4185D 02	1.9460D 09	0.9991	1.4000
28	3.5286D 01	-1.1340D 03	7.8222D-02	5.4929D 07	1.3740D 08	5.4950D 07	-1.1346D 03	3.5182D 02	1.9460D 09	0.9995	1.4000
29	3.6882D 01	-7.2947D 02	7.8159D-02	5.4868D 07	1.3720D 08	5.4888D 07	-7.2997D 02	3.6175D 02	1.9460D 09	0.9997	1.4000
30	3.8452D 01	-3.5302D 02	7.8106D-02	5.4816D 07	1.3705D 08	5.4836D 07	-3.5335D 02	3.7165D 02	1.9460D 09	0.9999	1.4000
31	4.0000D 01	0.0000D 00	7.8071D-02	5.4781D 07	1.3696D 08	5.4801D 07	0.0000D 00	3.8148D 02	1.9460D 09	1.0000	1.4000

TIMINGS AT CYCLE 601 TIME = 2.2397D-03

REZONE	TIMESTEP	CELL PRINT	LAYER PRNT	GRAPHICS	CHEMISTRY	DIFFUSION	CONDUCTION	ADINC
0.0000D 00	3.0745D-01	7.7701D-01	1.9021D-01	0.0000D 00	0.0000D 00	0.0000D 00	0.0000D 00	7.1902D 00

ADINC FREQUENCY COUNTERS (SINCE LAST CHECK) AT CYCLE 601
NO. CALLS = 600 NO. TIMESTEPS = 50 TOTAL NO. ITERATIONS = 200

LAYER BOUNDARY	INTER 1	INTER 2	INTER 3	INTER 4	INTER 5	INTER 6
INTERFACE POSITION	1.0000000D-20	2.8982385D 00	4.9314280D 00	2.6444627D 01	3.2004970D 01	4.0000000D 01
INTERFACE VELOCITY	0.0000000D 00	-8.3133524D 03	-1.3099457D 04	-2.4437875D 03	-2.8192427D 03	0.0000000D 00
INTERFACE AREA	6.2831853D-20	1.8210169D 01	3.0965079D 01	1.6615649D 02	2.0109316D 02	2.5132741D 02

	TOTALS	SHELL 1	SHELL 2	SHELL 3	SHELL 4	SHELL 5
THERMAL ERG	2.536601560 11	2.45702665D 09	3.08353465D 09	1.40382463D 05	2.85259137D 04	2.46119426D 11
KINETIC ERG	4.16537662D 10	7.29599601D 06	2.93688607D 07	2.20023299D 10	1.95277884D 10	8.69829096D 07
TOTAL ERG	2.95313922D 11	2.46432264D 09	3.11290351D 09	2.20024703D 10	1.95278171D 10	2.48206409D 11
VOL AVG RHO	2.03454375D 00	1.42860770D-02	9.4225P678D-03	1.00000099D 00	7.80000428D 00	7.81681735D-02
VOL AVG PRE	7.75420250D 07	6.20757807D 07	6.16563551D 07	9.94860728D 07	7.32914807D 07	5.48767441D 07
VOL AVG GAM	8.44870315D-01	1.66670000D 00	2.00000000D 00	5.00000000D-01	5.00000000D-01	1.40000000D 00
VOL AVG ENT	5.74575968D 10	7.38122794D 10	6.94444444D 11	1.00000107D 11	3.58057422D 10	1.94601532D 09
VOL AVG RHOC	2.00624871D 00	0.00000000D 00	0.00000000D 00	1.00000000D 00	7.80000000D 00	0.00000000D 00
LAYER VOLUME	5.02654825D 03	2.63887083D 01	5.00116273D 01	2.12057294D 03	1.02101705D 03	1.80855792D 03
LAYER MASS	1.02267323D 04	3.76991118D-01	4.71238898D-01	2.12057504D 03	7.96393738D 03	1.41371669D 02

AFTER STEP NO. 650 DT = 0.29919373D-05 THE TIME IS 0.23761008D-02

I	POSITION	VELOCITY	DENSITY	PRESSURE	ENERGY	AVG PRESS	AVG VELOC	CELL VOLUME	ENTROPY	THFRAC	GAMMA
1	1.0000D-20	0.0000D 00	2.1399D 68	2.1399D 68	2.1399D 68	2.1399D 68	0.0000D 00	2.1399D 68	2.1399D 68	**********	
2	5.0992D-01	-4.0115D 03	5.1278D-02	5.2236D 08	7.8391D 08	5.0577D 08	-3.8148D 03	8.1688D-01	7.3812D 10	0.9995	1.6667
3	1.0172D 00	-8.0628D 03	5.1631D-02	5.2836D 08	7.9386D 08	5.1096D 08	-7.8306D 03	2.4339D 00	7.3812D 10	0.9983	1.6667
4	1.5223D 00	-1.2153D 04	5.1982D-02	5.3437D 08	8.0460D 08	5.1630D 08	-1.1962D 04	4.0291D 00	7.3812D 10	0.9962	1.6667
5	2.1778D 00	-1.5877D 04	2.7836D-02	5.3785D 08	5.4083D 08	5.1967D 08	-1.5760D 04	7.6197D 00	6.9444D 11	0.9945	2.0000
6	2.7754D 00	-1.9510D 04	2.7871D-02	5.3942D 08	5.4399D 08	5.2127D 08	-1.9417D 04	9.2994D 00	6.9444D 11	0.9916	2.0000
7	3.1156D 00	-1.7384D 04	1.0000D 00	5.5119D 08	1.6902D 08	5.3294D 08	-1.7334D 04	6.2970D 00	1.0000D 11	0.0001	0.5000
8	3.9716D 00	-1.3643D 04	1.0000D 00	5.7165D 08	1.1687D 08	5.5372D 08	-1.3642D 04	1.9058D 01	1.0000D 11	0.0001	0.5000
9	5.1051D 00	-1.0618D 04	1.0000D 00	5.7148D 08	7.1312D 07	5.5477D 08	-1.0635D 04	3.2322D 01	1.0000D 11	0.0002	0.5000
10	6.3906D 00	-8.4843D 03	1.0000D 00	5.5406D 08	4.4490D 07	5.3873D 08	-8.5069D 03	4.6424D 01	1.0000D 11	0.0003	0.5000
11	7.7768D 00	-6.9738D 03	1.0000D 00	5.3018D 08	2.9311D 07	5.1608D 08	-6.9964D 03	6.1699D 01	1.0000D 11	0.0003	0.5000
12	9.2445D 00	-5.8683D 03	1.0000D 00	5.0502D 08	2.0319D 07	4.9195D 08	-5.8892D 03	7.8482D 01	1.0000D 11	0.0004	0.5000
13	1.0788D 01	-5.0303D 03	1.0000D 00	4.8047D 08	1.4679D 07	4.6830D 08	-5.0493D 03	9.7198D 01	1.0000D 11	0.0005	0.5000
14	1.2406D 01	-4.3754D 03	1.0000D 00	4.5714D 08	1.0958D 07	4.4575D 08	-4.3925D 03	1.1791D 02	1.0000D 11	0.0006	0.5000
15	1.4102D 01	-3.8504D 03	1.0000D 00	4.3514D 08	8.3945D 06	4.2445D 08	-3.8658D 03	1.4123D 02	1.0000D 11	0.0007	0.5000
16	1.5879D 01	-3.4205D 03	1.0000D 00	4.1442D 08	6.5668D 06	4.0437D 08	-3.4344D 03	1.6740D 02	1.0000D 11	0.0007	0.5000
17	1.7742D 01	-3.0624D 03	1.0000D 00	3.9486D 08	5.2256D 06	3.8539D 08	-3.0750D 03	1.9674D 02	1.0000D 11	0.0008	0.5000
18	1.9694D 01	-2.7598D 03	1.0000D 00	3.7634D 08	4.2179D 06	3.6741D 08	-2.7712D 03	2.2961D 02	1.0000D 11	0.0008	0.5000
19	2.1740D 01	-2.5010D 03	1.0000D 00	3.5876D 08	3.4458D 06	3.5032D 08	-2.5114D 03	2.6633D 02	1.0000D 11	0.0009	0.5000
20	2.3884D 01	-2.2774D 03	1.0000D 00	3.4201D 08	2.8442D 06	3.3405D 08	-2.2868D 03	3.0724D 02	1.0000D 11	0.0009	0.5000
21	2.6128D 01	-2.0825D 03	1.0000D 00	3.2602D 08	2.3689D 06	3.1850D 08	-2.0912D 03	3.5268D 02	1.0000D 11	0.0010	0.5000
22	2.6641D 01	-2.0427D 03	7.8001D 00	3.0501D 08	1.6591D 07	2.9808D 08	-2.0512D 03	8.4925D 01	3.5806D 10	0.0001	0.5000
23	2.7571D 01	-1.9739D 03	7.8001D 00	2.6850D 08	1.5722D 07	2.6258D 08	-1.9821D 03	1.5853D 02	3.5806D 10	0.0001	0.5000
24	2.8767D 01	-1.8921D 03	7.8000D 00	2.1635D 08	1.4560D 07	2.1187D 08	-1.9000D 03	2.1153D 02	3.5806D 10	0.0000	0.5000
25	3.0169D 01	-1.8042D 03	7.8000D 00	1.5515D 08	1.3307D 07	1.5236D 08	-1.8118D 03	2.5961D 02	3.5806D 10	0.0000	0.5000
26	3.1744D 01	-1.7147D 03	7.8000D 00	8.8107D 07	1.2058D 07	8.7159D 07	-1.7219D 03	3.0642D 02	3.5806D 10	0.0000	0.5000
27	3.3457D 01	-1.6119D 03	7.6300D-02	5.3049D 07	1.3272D 08	5.3062D 07	-1.6147D 03	3.5080D 02	1.9460D 09	0.9993	1.4000
28	3.5137D 01	-1.0486D 03	7.6017D-02	5.2774D 07	1.3199D 08	5.2792D 07	-1.0499D 03	3.6203D 02	1.9460D 09	0.9996	1.4000
29	3.6786D 01	-6.8466D 02	7.5893D-02	5.2654D 07	1.3166D 08	5.2673D 07	-6.8512D 02	3.7255D 02	1.9460D 09	0.9998	1.4000
30	3.8406D 01	-3.3447D 02	7.5849D-02	5.2611D 07	1.3154D 08	5.2631D 07	-3.3455D 02	3.8271D 02	1.9460D 09	0.9999	1.4000
31	4.0000D 01	0.0000D 00	7.5841D-02	5.2603D 07	1.3151D 08	5.2623D 07	0.0000D 00	3.9270D 02	1.9460D 09	1.0000	1.4000

TIMINGS AT CYCLE 651 TIME = 2.3761D-03

REZONE	TIMESTEP	CELL PRINT	LAYER PRNT	GRAPHICS	CHEMISTRY	DIFFUSION	CONDUCTION	ADINC
0.0000D 00	3.3302D-01	8.4242D-01	2.0611D-01	0.0000D 00	0.0000D 00	0.0000D 00	0.0000D 00	7.8869D 00

ADINC FREQUENCY COUNTERS (SINCE LAST CHECK) AT CYCLE 651
NO. CALLS = 650 NO. TIMESTEPS = 50 TOTAL NO. ITERATIONS = 200

LAYER BOUNDARY	INTER 1	INTER 2	INTER 3	INTER 4	INTER 5	INTER 6
INTERFACE POSITION	1.00000000D-20	1.52225122D 00	2.77539088D 00	2.61283726D 01	3.17441435D 01	4.00000000D 01
INTERFACE VELOCITY	0.00000000D 00	-1.21531133D 04	-1.95095279D 04	-2.08254171D 03	-1.71472686D 03	0.00000000D 00
INTERFACE AREA	6.28318531D-20	9.56458653D 00	1.74382952D 01	1.64169407D 02	1.99454336D 02	2.51327412D 02

	TOTALS	SHELL 1	SHELL 2	SHELL 3	SHELL 4	SHELL 5
THERMAL ERG	2.60232899D 11	5.79825605D 09	9.11465867D 09	9.63942284D 06	5.86652366D 05	2.45309758D 11
KINETIC ERG	3.49623567D 10	1.60610219D 07	6.51462825D 07	2.06814867D 10	1.41299723D 10	6.96904535D 07
TOTAL ERG	2.95195255D 11	5.81431707D 09	9.17980496D 09	2.06911261D 10	1.41305589D 10	2.45379448D 11
VOL AVG RHO	2.03454375D 00	5.17855486D-02	2.78523306D-02	1.00001621D 00	7.80002892D 00	7.59738130D-02
VOL AVG PRE	2.25723350D 08	5.31013189D 08	5.38717173D 08	3.97066590D 08	1.77773498D 08	5.27322561D 07
VOL AVG GAM	8.39912669D-01	1.66670000D 00	2.00000000D 00	5.00000000D-01	5.00000000D-01	1.40000000D 00
VOL AVG ENT	5.26246549D 10	7.38122794D 10	6.94444444D 11	1.00000107D 11	3.58057422D 10	1.94601532D 09
VOL AVG RHOC	2.00623729D 00	0.00000000D 00	0.00000000D 00	1.00000000D 00	7.80000000D 00	0.00000000D 00
LAYER VOLUME	5.02654825D 03	7.27985178D 00	1.69191909D 01	2.12054067D 03	1.02101383D 03	1.86079471D 03
LAYER MASS	1.02267323D 04	3.76991118D-01	4.71238898D-01	2.12057504D 03	7.96393738D 03	1.41371669D 02

AFTER STEP NO. 661 DT = [illegible] THE TIME IS 0.24076342D-02

I	POSITION	VELOCITY	DENSITY	PRESSURE	ENERGY	AVG PRESS	AVG VELOC	CELL VOLUME	ENTROPY	THFRAC	GAMMA
1	1.00000D-20	0.00000D 00	2.13990D 08	2.13990D 08	2.13990D 08	2.13990D 08	0.00000D 00	2.13990D 08	2.13990D 08	**********	
2	3.75340D-01	-4.59760D 03	9.46415E-02	1.45060D 09	2.17690D 09	1.37910D 09	-4.46660D 03	4.42600D-01	7.38120 10	0.9995	1.6667
3	7.50220D-01	-9.11670D 03	9.47980D-02	1.45470D 09	2.18590D 09	1.37420D 09	-8.89650D 03	1.32560D 00	7.38120 10	0.9985	1.6667
4	1.12470D 00	-1.33150D 04	9.49420D-02	1.45840D 09	2.19430D 09	1.37980D 09	-1.31210D 04	2.20660D 00	7.38120 10	0.9969	1.6667
5	1.65440D 00	-1.72770D 04	4.58570D-02	1.46030D 09	1.46610D 09	1.38380D 09	-1.71770D 04	4.62440D 00	6.94440 11	0.9960	2.0000
6	2.12970D 00	-2.10720D 04	4.58600D-02	1.46090D 09	1.46970D 09	1.38540D 09	-2.10640D 04	5.65080D 00	6.94440 11	0.9940	2.0000
7	2.55730D 00	-1.75650D 04	1.46020D 00	1.46020D 09	1.83770D 08	1.38650D 09	-1.76350D 04	6.29580D 00	1.00000 11	0.0011	0.5000
8	3.55040D 00	-1.26700D 04	1.00020D 00	1.42430D 09	1.08540D 08	1.35680D 09	-1.27830D 04	1.90550D 01	1.00000 11	0.0018	0.5000
9	4.78460D 00	-9.41630D 03	1.00020D 00	1.33520D 09	5.85060D 07	1.27570D 09	-9.52210D 03	3.23180D 01	1.00000 11	0.0027	0.5000
10	6.13740D 00	-7.35210D 03	1.00020D 00	1.23850D 09	3.42110D 07	1.18540D 09	-7.44280D 03	4.64190D 01	1.00000 11	0.0037	0.5000
11	7.57000D 00	-5.97090D 03	1.00010D 00	1.15030D 09	2.18120D 07	1.10220D 09	-6.04750D 03	6.16930D 01	1.00000 11	0.0047	0.5000
12	9.07110D 00	-4.99190D 03	1.00010D 00	1.07230D 09	1.48640D 07	1.02830D 09	-5.05690D 03	7.84750D 01	1.00000 11	0.0055	0.5000
13	1.06390D 01	-4.26430D 03	1.00010D 00	1.00320D 09	1.06440D 07	9.62650D 08	-4.32010D 03	9.71000D 01	1.00000 11	0.0063	0.5000
14	1.22770D 01	-3.70290D 03	1.00010D 00	9.41510D 08	7.91960D 06	9.03880D 08	-3.75120D 03	1.17900D 02	1.00000 11	0.0070	0.5000
15	1.39880D 01	-3.25670D 03	1.00010D 00	8.85810D 08	6.05050D 06	8.50750D 08	-3.29890D 03	1.41220D 02	1.00000 11	0.0077	0.5000
16	1.57780D 01	-2.89360D 03	1.00010D 00	8.35050D 08	4.73370D 06	8.02280D 08	-2.93070D 03	1.67390D 02	1.00000 11	0.0082	0.5000
17	1.76520D 01	-2.59250D 03	1.00010D 00	7.88410D 08	3.77170D 06	7.57710D 08	-2.62520D 03	1.96740D 02	1.00000 11	0.0087	0.5000
18	1.96130D 01	-2.33870D 03	1.00010D 00	7.45290D 08	3.05070D 06	7.16480D 08	-2.36790D 03	2.29860D 02	1.00000 11	0.0090	0.5000
19	2.16660D 01	-2.12220D 03	1.00000D 00	7.05190D 08	2.49880D 06	6.78120D 08	-2.14820D 03	2.66320D 02	1.00000 11	0.0094	0.5000
20	2.38170D 01	-1.93540D 03	1.00000D 00	6.67770D 08	2.06890D 06	6.42300D 08	-1.95870D 03	3.07230D 02	1.00000 11	0.0096	0.5000
21	2.60670D 01	-1.77280D 03	1.00000D 00	6.32710D 08	1.72900D 06	6.08720D 08	-1.79370D 03	3.52670D 02	1.00000 11	0.0098	0.5000
22	2.85800D 01	-1.63950D 03	7.80030D 00	5.87630D 08	1.20400D 07	5.65430D 08	-1.75990D 03	8.49230D 01	3.58060 10	0.0011	0.5000
23	2.75130D 01	-1.68170D 03	7.80020D 00	5.69320D 08	1.14150D 07	4.90470D 08	-1.70140D 03	1.58530D 02	3.58060 10	0.0008	0.5000
24	2.87110D 01	-1.61250D 03	7.80010D 00	3.98210D 08	1.05760D 07	3.83970D 08	-1.63130D 03	2.11530D 02	3.58060 10	0.0004	0.5000
25	3.01160D 01	-1.53780D 03	7.80010D 00	2.68470D 08	9.66650D 06	2.59590D 08	-1.55560D 03	2.59600D 02	3.58060 10	0.0001	0.5000
26	3.16940D 01	-1.46130D 03	7.80000D 00	1.26800D 08	8.75810D 06	1.23760D 08	-1.47820D 03	3.06420D 02	3.58060 10	0.0000	0.5000
27	3.34140D 01	-1.32560D 03	7.60870D-02	5.28420D 07	1.32180D 08	5.28470D 07	-1.33080D 03	3.51780D 02	1.94600 09	0.9994	1.4000
28	3.51040D 01	-1.01280D 03	7.56180D-02	5.23870D 07	1.31020D 08	5.24040D 07	-1.01480D 03	3.63940D 02	1.94600 09	0.9996	1.4000
29	3.67640D 01	-6.71340D 02	7.54410D-02	5.22150D 07	1.30560D 08	5.22350D 07	-6.72110D 02	3.74790D 02	1.94600 09	0.9998	1.4000
30	3.83950D 01	-3.31130D 02	7.53740D-02	5.21510D 07	1.30390D 08	5.21720D 07	-3.31370D 02	3.85120D 02	1.94600 09	0.9999	1.4000
31	4.00000D 01	0.00000D 00	7.53540D-02	5.21310D 07	1.30330D 08	5.21540D 07	0.00000D 00	3.95230D 02	1.94600 09	1.0000	1.4000

TIMINGS AT CYCLE 661 TIME = 2.40761D-03

REZONE	TIMESTEP	CELL PRINT	LAYER PRNT	GRAPHICS	CHEMISTRY	DIFFUSION	CONDUCTION	ADINC
0.00000D 00	3.38140D-01	9.72280D-01	2.37900D-01	0.00000D 00	0.00000D 00	0.00000D 00	0.00000D 00	8.03400D 00

ADINC FREQUENCY COUNTERS (SINCE LAST CHECK) AT CYCLE 661
NO. CALLS = 660 NO. TIMESTEPS = 5 TOTAL NO. ITERATIONS = 23

LAYER BOUNDARY	INTER 1	INTER 2	INTER 3	INTER 4	INTER 5	INTER 6
INTERFACE POSITION	1.00000000D-20	1.12472799D 00	2.12972100D 00	2.60670248D 01	3.16936227D 01	4.00000000D 01
INTERFACE VELOCITY	0.00000000D 00	-1.33146994D 04	-2.10724118D 04	-1.77284456D 03	-1.46127644D 03	0.00000000D 00
INTERFACE AREA	6.28318531D-20	7.06687437D 00	1.33814317D 01	1.63783947D 02	1.99136904D 02	2.51327412D 02

	TOTALS	SHELL 1	SHELL 2	SHELL 3	SHELL 4	SHELL 5
THERMAL ERG	2.68559920D 11	8.68066421D 09	1.50082278D 10	8.58743253D 07	3.81150444D 06	2.44781342D 11
KINETIC ERG	2.65116865D 10	1.97462513D 07	7.69187419D 07	1.60966296D 10	1.02584117D 10	5.99801479D 07
TOTAL ERG	2.95071606D 11	8.70041047D 09	1.50851466D 10	1.61825040D 10	1.02622232D 10	2.44841322D 11
VOL AVG RHO	2.03454375D 00	9.48606816D-02	4.58617630D-02	1.00006805D 00	7.80009749D 00	7.55649384D-02
VOL AVG PRE	4.27696305D 08	1.45625871D 09	1.46062601D 09	8.05359542D 08	3.16765210D 08	5.23354845D 07
VOL AVG GAM	8.38965495D-01	1.66670000D 00	2.00000000D 00	5.00000000D-01	5.00000000D-01	1.40000000D 00
VOL AVG ENT	5.16598573D 10	7.38122794D 10	6.94444444D 11	1.00000107D 11	3.58057422D 10	1.94601532D 09
VOL AVG RHOC	2.00620149D 00	0.00000000D 00	0.00000000D 00	1.00000000D 00	7.80000000D 00	0.00000000D 00
LAYER VOLUME	5.02654825D 03	3.97415569D 00	1.02752024D 01	2.12043075D 03	1.02100485D 03	1.87086329D 03
LAYER MASS	1.02267323D 04	3.76991118D-01	4.71238895D-01	2.12057504D 03	7.96393738D 03	1.41371669D 02

AFTER STEP NO. 665 DT = 0.34996903D-05 THE TIME IS 0.24254122D-02

I	POSITION	VELOCITY	DENSITY	PRESSURE	ENERGY	AVG PRESS	AVG VELOC	CELL VOLUME	ENTROPY	THERAC	GAMMA
1	1.0000D-20	0.0000D 00	2.1399D 68	2.1399D 68	2.1399D 68	2.1399D 68	0.0000D 00	2.1399D 68	2.1399D 68	**********	**********
2	3.0337D-01	-3.8109D 03	1.4487D-01	2.9495D 09	4.4251D 09	2.9495D 09	-3.8109D 03	2.8913D-01	7.3812D 10	0.9998	1.6667
3	6.0663D-01	-7.5252D 03	1.4494D-01	2.9518D 09	4.4309D 09	2.9518D 09	-7.5252D 03	8.6699D-01	7.3812D 10	0.9993	1.6667
4	9.0992D-01	-1.1161D 04	1.4494D-01	2.9519D 09	4.4349D 09	2.9519D 09	-1.1161D 04	1.4450D 00	7.3812D 10	0.9984	1.6667
5	1.3652D 00	-1.5002D 04	6.5158D-02	2.9483D 09	2.9545D 09	2.9483D 09	-1.5002D 04	3.2545D 00	6.9444D 11	0.9979	2.0000
6	1.7696D 00	-1.8651D 04	6.5086D-02	2.9418D 09	2.9515D 09	2.9418D 09	-1.8651D 04	3.9821D 00	6.9444D 11	0.9967	2.0000
7	2.2659D 00	-1.4692D 04	1.0008D 00	2.8652D 09	1.3655D 08	2.8652D 09	-1.4692D 04	6.2920D 00	1.0000D 11	0.0115	0.5000
8	3.3461D 00	-1.0047D 04	1.0007D 00	2.6569D 09	7.2303D 07	2.6569D 09	-1.0047D 04	1.9946D 01	1.0000D 11	0.0173	0.5000
9	4.6346D 00	-7.3079D 03	1.0006D 00	2.3982D 09	3.6672D 07	2.3982D 09	-7.3079D 03	3.2305D 01	1.0000D 11	0.0251	0.5000
10	6.0208D 00	-5.6645D 03	1.0005D 00	2.1764D 09	2.1036D 07	2.1764D 09	-5.6645D 03	4.6404D 01	1.0000D 11	0.0327	0.5000
11	7.4755D 00	-4.5945D 03	1.0004D 00	1.9931D 09	1.3390D 07	1.9931D 09	-4.5945D 03	6.1676D 01	1.0000D 11	0.0394	0.5000
12	8.9920D 00	-3.8476D 03	1.0003D 00	1.8388D 09	9.1787D 06	1.8388D 09	-3.8476D 03	7.8457D 01	1.0000D 11	0.0452	0.5000
13	1.0572D 01	-3.2976D 03	1.0003D 00	1.7061D 09	6.6338D 06	1.7061D 09	-3.2976D 03	9.7082D 01	1.0000D 11	0.0499	0.5000
14	1.2218D 01	-2.8757D 03	1.0003D 00	1.5899D 09	4.9847D 06	1.5899D 09	-2.8757D 03	1.1788D 02	1.0000D 11	0.0537	0.5000
15	1.3937D 01	-2.5416D 03	1.0002D 00	1.4865D 09	3.8576D 06	1.4865D 09	-2.5416D 03	1.4120D 02	1.0000D 11	0.0568	0.5000
16	1.5732D 01	-2.2702D 03	1.0002D 00	1.3935D 09	3.0548D 06	1.3935D 09	-2.2702D 03	1.6737D 02	1.0000D 11	0.0591	0.5000
17	1.7610D 01	-2.0453D 03	1.0002D 00	1.3091D 09	2.4638D 06	1.3091D 09	-2.0453D 03	1.9671D 02	1.0000D 11	0.0607	0.5000
18	1.9575D 01	-1.8559D 03	1.0002D 00	1.2320D 09	2.0172D 06	1.2320D 09	-1.8559D 03	2.2958D 02	1.0000D 11	0.0618	0.5000
19	2.1632D 01	-1.6941D 03	1.0001D 00	1.1611D 09	1.6724D 06	1.1611D 09	-1.6941D 03	2.6630D 02	1.0000D 11	0.0624	0.5000
20	2.3786D 01	-1.5544D 03	1.0001D 00	1.0956D 09	1.4013D 06	1.0956D 09	-1.5544D 03	3.0721D 02	1.0000D 11	0.0626	0.5000
21	2.6038D 01	-1.4326D 03	1.0001D 00	1.0351D 09	1.1850D 06	1.0351D 09	-1.4326D 03	3.5264D 02	1.0000D 11	0.0624	0.5000
22	2.6552D 01	-1.4074D 03	7.8007D 00	9.5794D 08	7.9220D 06	9.5794D 08	-1.4074D 03	8.4918D 01	3.5806D 10	0.0074	0.5000
23	2.7486D 01	-1.3630D 03	7.8005D 00	8.2478D 08	7.5169D 06	8.2478D 08	-1.3630D 03	1.5852D 02	3.5806D 10	0.0050	0.5000
24	2.8685D 01	-1.3085D 03	7.8003D 00	6.3629D 08	6.9699D 06	6.3629D 08	-1.3085D 03	2.1152D 02	3.5806D 10	0.0025	0.5000
25	3.0091D 01	-1.2486D 03	7.8001D 00	4.1684D 08	6.3733D 06	4.1684D 08	-1.2486D 03	2.5960D 02	3.5806D 10	0.0008	0.5000
26	3.1670D 01	-1.1866D 03	7.8000D 00	1.7765D 08	5.7746D 06	1.7765D 08	-1.1866D 03	3.0642D 02	3.5806D 10	0.0001	0.5000
27	3.3391D 01	-1.2497D 03	7.6116D-02	5.2865D 07	1.3222D 08	5.2865D 07	-1.2497D 03	3.5168D 02	1.9460D 09	0.9996	1.4000
28	3.5086D 01	-9.8510D 02	7.5434D-02	5.2208D 07	1.3057D 08	5.2208D 07	-9.8510D 02	3.6483D 02	1.9460D 09	0.9996	1.4000
29	3.6752D 01	-6.6072D 02	7.5204D-02	5.1985D 07	1.2999D 08	5.1985D 07	-6.6072D 02	3.7597D 02	1.9460D 09	0.9998	1.4000
30	3.8389D 01	-3.2757D 02	7.5117D-02	5.1901D 07	1.2976D 08	5.1901D 07	-3.2757D 02	3.8644D 02	1.9460D 09	0.9999	1.4000
31	4.0000D 01	0.0000D 00	7.5086D-02	5.1872D 07	1.2968D 08	5.1872D 07	0.0000D 00	3.9664D 02	1.9460D 09	1.0000	1.4000

TIMINGS AT CYCLE 666 TIME = 2.4254D-03

REZONE	TIMESTEP	CELL PRINT	LAYER PRNT	GRAPHICS	CHEMISTRY	DIFFUSION	CONDUCTION	ADINC
0.0000D 00	3.4070D-01	1.1024D 00	2.6969D-01	0.0000D 00	0.0000D 00	0.0000D 00	0.0000D 00	8.1164D 00

ADINC FREQUENCY COUNTERS (SINCE LAST CHECK) AT CYCLE 666
NO. CALLS = 665 NO. TIMESTEPS = 1 TOTAL NO. ITERATIONS = 5

LAYER BOUNDARY	INTER 1	INTER 2	INTER 3	INTER 4	INTER 5	INTER 6
INTERFACE POSITION	1.0000000D-20	9.6992B856D-01	1.7695907ID 00	2.6038444 7D 01	3.1670020 9D 01	4.0000000D 01
INTERFACE VELOCITY	0.0000000D 00	-1.1160544 2D 04	-1.8651444 7D 04	-1.4325985 9D 03	-1.1865528 8D 03	0.0000000D 00
INTERFACE AREA	0.2831853 1D-20	5.7172013 5D 00	1.1118666 4D 01	1.6361437 3D 02	1.9808861 6D 02	2.5132741 2D 02

	TOTALS	SHELL 1	SHELL 2	SHELL 3	SHELL 4	SHELL 5
THERMAL ERG	2.7780210D 11	1.1515531 8D 10	2.1309962 9D 10	4.2399291 6D 08	1.5916525 2D 07	2.4453670 6D 11
KINETIC ERG	1.6918962 3D 10	1.3715791 8D 07	5.8767519 7D 07	1.0048179 9D 10	6.7466587 5D 09	5.1640332 1D 07
TOTAL ERG	2.9472196 2D 11	1.1529247 5D 10	2.1368730 4D 10	1.0472172 6D 10	6.7625627 7D 09	2.4458834 6D 11
VOL AVG RHO	2.0345437 5D 00	1.4493524 0D-01	6.5118430 4D-02	1.0001938 8D 00	7.8002491 9D 00	7.5375649 9D-02
VOL AVG PRE	6.9585294 0D 08	2.9515989 1D 09	2.9447308 3D 09	1.3497100 1D 09	4.9886118 4D 08	5.2152211 9D 07
VOL AVG GAM	8.3858126 2D-01	1.6667000 0D 00	2.0000000 0D 00	5.0000000 0D-01	5.0000000 0D-01	1.4000000 0D 00
VOL AVG ENT	5.1216271 9D 10	7.3812279 4D 10	6.9444444 4D 11	1.0000010 7D 11	3.5805742 2D 10	1.9460153 2D 09
VOL AVG RHOC	2.0061176 1D 00	0.0000000 0D 00	0.0000000 0D 00	1.0000000 0D 00	7.8000000 0D 00	0.0000000 0D 00
LAYER VOLUME	5.0265482 5D 03	2.6011003 7D 00	7.2366439 9D 00	2.1201639 7D 03	1.5209849 8D 03	1.8756153 2D 03
LAYER MASS	1.0226732 3D 04	3.7699111 8D-01	4.7123889 8D-01	2.1205750 4D 03	7.9639373 8D 03	1.3137169 9D 02

AFTER STEP NO. 670 DT = 0.4987612?0-05 THE TIME IS 0.24448016D-02

I	POSITION	VELOCITY	DENSITY	PRESSURE	ENERGY	AVG PRESS	AVG VELOC	CELL VOLUME	ENTROPY	THERAC	GAMMA
1	1.0000D-20	0.0000D 00	2.1399D 68	2.1399D 68	2.1399D 68	2.1399D 68	0.0000D 00	2.1399D 68	2.1399D 68	**********	**********
2	2.5534D-01	-1.4383D 03	2.0451D-01	5.2395D 09	7.8591D 09	5.2395D 09	-1.4303D 03	2.0482D-01	7.3812D 10	1.0000	1.6667
3	5.1090D-01	-2.8605D 03	2.0427D-01	5.2294D 09	7.8443D 09	5.2294D 09	-2.8605D 03	6.1518D-01	7.3812D 10	0.9999	1.6667
4	7.6681D-01	-4.2904D 03	2.0389D-01	5.2131D 09	7.8208D 09	5.2131D 09	-4.2904D 03	1.0272D 00	7.3812D 10	0.9998	1.6667
5	1.1698D 00	-5.9122D 03	8.6478D-02	5.1933D 09	5.1946D 09	5.1933D 09	-5.9122D 03	2.4522D 00	6.9444D 11	0.9998	2.0000
6	1.5246D 00	-7.4444D 03	8.6366D-02	5.1728D 09	5.1748D 09	5.1728D 09	-7.4444D 03	3.0030D 00	6.9444D 11	0.9996	2.0000
7	2.0794D 00	-5.5248D 03	1.0025D 00	4.9854D 09	2.8366D 07	4.9854D 09	-5.5248D 03	6.2615D 00	1.0000D 11	0.2911	0.5000
8	3.2215D 00	-3.6435D 03	1.0021D 00	4.5490D 09	1.5870D 07	4.5490D 09	-3.6435D 03	1.9020D 01	1.0000D 11	0.3953	0.5000
9	4.5442D 00	-2.6518D 03	1.0017D 00	4.0776D 09	9.2078D 06	4.0776D 09	-2.6518D 03	3.2270D 01	1.0000D 11	0.4907	0.5000
10	5.9504D 00	-2.0883D 03	1.0014D 00	3.7090D 09	6.0944D 06	3.7090D 09	-2.0883D 03	4.6362D 01	1.0000D 11	0.5539	0.5000
11	7.4179D 00	-1.7337D 03	1.0012D 00	3.3954D 09	4.3972D 06	3.3954D 09	-1.7337D 03	6.1630D 01	1.0000D 11	0.5934	0.5000
12	8.9433D 00	-1.4925D 03	1.0010D 00	3.1412D 09	3.3484D 06	3.1412D 09	-1.4925D 03	7.8407D 01	1.0000D 11	0.6170	0.5000
13	1.0529D 01	-1.3187D 03	1.0009D 00	2.9227D 09	2.6417D 06	2.9227D 09	-1.3187D 03	9.7027D 01	1.0000D 11	0.6299	0.5000
14	1.2181D 01	-1.1875D 03	1.0008D 00	2.7305D 09	2.1361D 06	2.7305D 09	-1.1878D 03	1.1783D 02	1.0000D 11	0.6353	0.5000
15	1.3903D 01	-1.0856D 03	1.0007D 00	2.5587D 09	1.7587D 06	2.5587D 09	-1.0856D 03	1.4114D 02	1.0000D 11	0.6349	0.5000
16	1.5702D 01	-1.0036D 03	1.0006D 00	2.4030D 09	1.4679D 06	2.4030D 09	-1.0036D 03	1.6730D 02	1.0000D 11	0.6302	0.5000
17	1.7583D 01	-9.3622D 02	1.0005D 00	2.2606D 09	1.2385D 06	2.2606D 09	-9.3622D 02	1.9665D 02	1.0000D 11	0.6218	0.5000
18	1.9550D 01	-8.7960D 02	1.0005D 00	2.1294D 09	1.0544D 06	2.1294D 09	-8.7960D 02	2.2951D 02	1.0000D 11	0.6105	0.5000
19	2.1609D 01	-8.3116D 02	1.0004D 00	2.0079D 09	9.0435D 05	2.0079D 09	-8.3116D 02	2.6623D 02	1.0000D 11	0.5967	0.5000
20	2.3764D 01	-7.8903D 02	1.0004D 00	1.8948D 09	7.8073D 05	1.8948D 09	-7.8903D 02	3.0714D 02	1.0000D 11	0.5808	0.5000
21	2.6018D 01	-7.5182D 02	1.0003D 00	1.7892D 09	6.7788D 05	1.7892D 09	-7.5182D 02	3.5257D 02	1.0000D 11	0.5632	0.5000
22	2.8532D 01	-7.4353D 02	7.8221D 00	1.6535D 09	2.4819D 06	1.6535D 09	-7.4353D 02	8.4903D 01	3.5806D 10	0.1214	0.5000
23	2.7467D 01	-7.2657D 02	7.8216D 00	1.4189D 09	2.2970D 06	1.4189D 09	-7.2657D 02	1.5850D 02	3.5806D 10	0.0829	0.5000
24	2.8666D 01	-7.0236D 02	7.8209D 00	1.0860D 09	2.0748D 06	1.0860D 09	-7.0236D 02	2.1151D 02	3.5806D 10	0.0412	0.5000
25	3.0073D 01	-6.7242D 02	7.8204D 00	6.9771D 08	1.8635D 06	6.9771D 08	-6.7242D 02	2.5959D 02	3.5806D 10	0.0122	0.5000
26	3.1653D 01	-6.3930D 02	7.8199D 00	2.7414D 08	1.6768D 06	2.7414D 08	-6.3930D 02	3.0642D 02	3.5806D 10	0.0008	0.5000
27	3.3368D 01	-1.1166D 03	7.6480D-02	5.3156D 07	1.3292D 08	5.3156D 07	-1.1166D 03	3.5030D 02	1.9460D 09	0.9998	1.4000
28	3.5068D 01	-9.4287D 02	7.5295D-02	5.2074D 07	1.3023D 08	5.2074D 07	-9.4287D 02	3.6550D 02	1.9460D 09	0.9997	1.4000
29	3.6740D 01	-6.4466D 02	7.4966D-02	5.1756D 07	1.2941D 08	5.1756D 07	-6.4466D 02	3.7716D 02	1.9460D 09	0.9998	1.4000
30	3.8383D 01	-3.2159D 02	7.4845D-02	5.1639D 07	1.2911D 08	5.1639D 07	-3.2159D 02	3.8784D 02	1.9460D 09	0.9999	1.4000
31	4.0000D 01	0.0000D 00	7.4806D-02	5.1595D 07	1.2899D 08	5.1595D 07	0.0000D 00	3.9816D 02	1.9460D 09	1.0000	1.4000

TIMINGS AT CYCLE 671 TIME = 2.4448[-03

REZONE	TIMESTEP	CELL PRINT	LAYER PRNT	GRAPHICS	CHEMISTRY	DIFFUSION	CONDUCTION	ADINC
0.0000D 00	3.4325[-01	1.4282[00	3.4907D-01	0.0000D 00	0.0000D 00	0.0000D 00	0.0000D 00	8.1963D 00

ADINC FREQUENCY COUNTERS (SINCE LAST CHECK) AT CYCLE 671
NO. CALLS = 670 NO. TIMESTEPS = 1 TOTAL NO. ITERATIONS = 4

LAYER BOUNDARY	INTER 1	INTER 2	INTER 3	INTER 4	INTER 5	INTER 6
INTERFACE POSITION	1.0000000D-20	7.6684501?D-01	1.5246100?D 00	2.6018024?D 01	3.1652920?D 01	4.0000000D 01
INTERFACE VELOCITY	0.0000000D 00	-8.2904446D 03	-7.4444057?D 03	-7.5181723?D 02	-6.3930342?D 02	0.0000000D 00
INTERFACE AREA	6.2831853?D-20	4.6179780?D 00	9.5794072?D 00	1.6347606?D 02	1.9888116?D 02	2.5132741?D 02

	TOTALS	SHELL 1	SHELL 2	SHELL 3	SHELL 4	SHELL 5
THERMAL ERG	2.6932481?D 11	1.4467?7780 10	2.8268120?D 10	2.1467133?D 09	8.0132319?D 07	2.4436198?D 11
KINETIC ERG	3.6351796?D 09	2.?8?001690 06	9.2150187?D 06	1.6534422?D 09	1.9310689?D 09	3.9445376?D 07
TOTAL ERG	2.9295992?D 11	1.4469?8590 10	2.8278127?D 10	3.8001556?D 09	2.0112012?D 09	2.4440142?D 11
VOL AVG RHO	2.0345437?D 00	2.?485127?D-01	8.6383478?D-02	1.0005734?D 00	7.8007258?D 00	7.5239179?D-02
VOL AVG PRE	1.1780176?D 09	5.221454?9? 09	5.1820069?D 09	2.3240967?D 09	8.4247973?D 08	5.2020592?D 07
VOL AVG GAM	8.3?48378?D-01	1.6667??00D 00	2.0000000?D 00	5.0000000?D-01	5.0000000?D-01	1.4000000?D 00
VOL AVG ENT	5.?9439594?D 10	7.3?122794?D 10	6.9444444?D 11	1.0000197?D 11	3.5805742?D 10	1.9460153?D 09
VOL AVG RHOC	2.0?586?79?D 00	0.0000000?D 00	0.0000000?D 00	1.0000000?D 00	7.8000000?D 00	0.0000000?D 00
LAYER VOLUME	5.0265?825?D 03	1.?47224?4D 00	5.4552?531D 00	2.1193597?D 03	1.0209226?D 03	1.?8796346D 03
LAYER MASS	1.0226?323?D 04	3.?0?911190-01	4.7123?898D-01	2.1205750?D 03	7.9639373?D 03	1.?1371669D 02

AFTER STEP NO. 671 DT = 0.53963742D-05 THE TIME IS 0.24497092D-02

I	POSITION	VELOCITY	DENSITY	PRESSURE	ENERGY	AVG PRESS	AVG VELOC	CELL VOLUME	ENTROPY	THFRAC	GAMMA
1	1.00000D-20	0.00000D 00	2.13990D 68	2.13990D 68	2.13990D 68	2.13990D 68	0.00000D 00	2.13990D 68	2.13990D 68	**********	**********
2	2.51840D-01	-7.11660D 02	2.10220D-01	5.48570D 09	8.22810D 09	5.48570D 09	-7.11660D 02	1.09260D-01	7.38120 10	1.0000	1.6667
3	5.03900D-01	-1.42480 03	2.09960D-01	5.47530 09	8.21260D 09	5.47530 09	-1.42480 03	5.98450D-01	7.38120 10	1.0000	1.6667
4	7.56300D-01	-2.14060 03	2.09600D-01	5.45860 09	8.18790 09	5.45860 09	-2.14060 03	9.99250D-01	7.38120 10	1.0000	1.6667
5	1.15530 00	-2.91660 03	8.58950D-02	5.43850 09	5.43850 09	5.43850 09	-2.91660 03	2.39630 00	6.94440 11	0.9999	2.0000
6	1.50630 00	-3.74010 03	8.83240D-02	5.41740 09	5.41860 09	5.41740 09	-3.74010 03	2.93440 00	6.94440 11	0.9999	2.0000
7	2.06590 00	-2.75870 03	1.00270 00	5.22600 09	1.45520 07	5.22600 09	-2.75870 03	6.28000 00	1.00000 11	0.6535	0.5000
8	3.21260 00	-1.82060 03	1.00230 00	4.79080 09	9.71930 06	4.79080 09	-1.82060 03	1.90150 01	1.00000 11	0.7539	0.5000
9	4.53760 00	-1.33810 03	1.00190 00	4.32740 09	6.58200 06	4.32740 09	-1.33810 03	3.22630 01	1.00000 11	0.8205	0.5000
10	5.94520 00	-1.07110 03	1.00160 00	3.95630 09	4.83020 06	3.95630 09	-1.07110 03	4.63530 01	1.00000 11	0.8544	0.5000
11	7.41340 00	-9.08360 02	1.00130 00	3.65510 09	3.73490 06	3.65510 09	-9.08360 02	6.16190 01	1.00000 11	0.8713	0.5000
12	8.93940 00	-8.01720 02	1.00120 00	3.40140 09	2.98400 06	3.40140 09	-8.01720 02	7.83930 01	1.00000 11	0.8790	0.5000
13	1.05260 01	-7.28050 02	1.00110 00	3.18130 09	2.43600 06	3.18130 09	-7.28050 02	9.70120 01	1.00000 11	0.8809	0.5000
14	1.21780 01	-6.75040 02	1.00090 00	2.98570 09	2.01870 06	2.98570 09	-6.75040 02	1.17810 02	1.00000 11	0.8788	0.5000
15	1.39000 01	-6.35590 02	1.00080 00	2.80890 09	1.69110 06	2.80890 09	-6.35590 02	1.41120 02	1.00000 11	0.8736	0.5000
16	1.56990 01	-6.05340 02	1.00070 00	2.64720 09	1.42840 06	2.64720 09	-6.05340 02	1.67280 02	1.00000 11	0.8657	0.5000
17	1.75800 01	-5.81470 02	1.00060 00	2.49760 09	1.21420 06	2.49760 09	-5.81470 02	1.96620 02	1.00000 11	0.8553	0.5000
18	1.95470 01	-5.62040 02	1.00060 00	2.35840 09	1.03750 06	2.35840 09	-5.62040 02	2.29490 02	1.00000 11	0.8428	0.5000
19	2.16060 01	-5.45720 02	1.00050 00	2.22800 09	8.90410 05	2.22800 09	-5.45720 02	2.66210 02	1.00000 11	0.8280	0.5000
20	2.37610 01	-5.31540 02	1.00040 00	2.10540 09	7.66990 05	2.10540 09	-5.31540 02	3.07110 02	1.00000 11	0.8111	0.5000
21	2.60150 01	-5.18760 02	1.00040 00	1.98970 09	6.62800 05	1.98970 09	-5.18760 02	3.52540 02	1.00000 11	0.7922	0.5000
22	2.65330 01	-5.15440 02	7.89260 00	1.87930 09	1.45790 06	1.87930 09	-5.15440 02	8.48970 01	3.58060 10	0.2845	0.5000
23	2.74640 01	-5.06860 02	7.88190 00	1.57870 09	1.28120 06	1.57870 09	-5.06860 02	1.58490 02	3.58060 10	0.2047	0.5000
24	2.86640 01	-4.92340 02	7.86110 00	1.20770 09	1.09030 06	1.20770 09	-4.92340 02	2.11500 02	3.58060 10	0.1077	0.5000
25	3.00700 01	-4.72450 02	7.84050 00	7.74060 08	9.37560 05	7.74060 08	-4.72450 02	2.59590 02	3.58060 10	0.0330	0.5000
26	3.16510 01	-4.49340 02	7.82010 00	3.00430 08	8.29190 05	3.00430 08	-4.49340 02	3.06420 02	3.58060 10	0.0022	0.5000
27	3.33630 01	-1.06960 03	7.65540D-02	5.32970 07	1.33270 08	5.32970 07	-1.06960 03	3.49640 02	1.94600 09	0.9998	1.4000
28	3.50630 01	-9.29210 02	7.52760D-02	5.20550 07	1.30170 08	5.20550 07	-9.29210 02	3.65590 02	1.94600 09	0.9997	1.4000
29	3.67370 01	-6.39620 02	7.49110D-02	5.17020 07	1.29280 08	5.17020 07	-6.39620 02	3.77440 02	1.94600 09	0.9998	1.4000
30	3.83620 01	-3.19680 02	7.47790D-02	5.15740 07	1.28950 08	5.15740 07	-3.19680 02	3.88190 02	1.94600 09	0.9999	1.4000
31	4.00000 01	0.00000 00	7.47290D-02	5.15270 07	1.28820 08	5.15270 07	0.00000 00	3.98540 02	1.94600 09	1.0000	1.4000

TIMINGS AT CYCLE 672 TIME = 2.4497D-03

REZONE	TIMESTEP	CELL PRINT	LAYER PRNT	GRAPHICS	CHEMISTRY	DIFFUSION	CONDUCTION	ADINC
0.00000 00	3.4377D-01	1.49340 00	3.64880D-01	0.0000D 00	0.0000D 00	0.0000D 00	0.0000D 00	8.2103D 00

ADINC FREQUENCY COUNTERS (SINCE LAST CHECK) AT CYCLE 672
NO. CALLS = 671 NO. TIMESTEPS = 1 TOTAL NO. ITERATIONS = 4

LAYER BOUNDARY	INTER 1	INTER 2	INTER 3	INTER 4	INTER 5	INTER 6
INTERFACE POSITION	1.00000000D-20	7.56299638D-01	1.50625492D 00	2.60154786D 01	3.16507150D 01	4.00000000D 01
INTERFACE VELOCITY	0.00000000D 00	-2.14062851D 03	-3.74012858D 03	-5.18759562D 02	-4.49337399D 02	0.00000000D 00
INTERFACE AREA	6.28318531D-20	4.75197677D 00	9.46407876D 00	1.63460073D 02	1.98867307D 02	2.51327412D 02

	TOTALS	SHELL 1	SHELL 2	SHELL 3	SHELL 4	SHELL 5
THERMAL ERG	2.90895912D 11	1.47356492D 10	2.89291636D 10	2.78052834D 09	1.10208795D 08	2.44340362D 11
KINETIC ERG	1.51457101D 09	4.99194551D 05	2.31766511D 06	5.30818614D 08	9.44682791D 08	3.62527416D 07
TOTAL ERG	2.92410483D 11	1.47361484D 10	2.89314812D 10	3.31134696D 09	1.05489159D 09	2.44376614D 11
VOL AVG RHO	2.03454375D 00	2.09794192D-01	8.84009288D-02	1.00068740D 00	7.80089692D 00	7.52216229D-02
VOL AVG PRE	1.29375435D 09	5.46716361D 09	5.42689700D 09	2.55380987D 09	9.35256640D 08	5.20038523D 07
VOL AVG GAM	8.38513487D-01	1.66670000D 00	2.00000000D 00	5.00000000D-01	5.00000000D-01	1.40000000D 00
VOL AVG ENT	5.09212282D 10	7.38122794D 10	6.94444444D 11	1.00000107D 11	3.58057422D 10	1.94601532D 09
VOL AVG RHOC	2.00577804D 00	0.00000000D 00	0.00000000D 00	1.00000000D 00	7.80000000D 00	0.00000000D 00
LAYER VOLUME	5.02654825D 03	1.79695689D 00	5.33070069D 00	2.11911836D 03	1.02090022D 03	1.87940201D 03
LAYER MASS	1.02267323D 04	3.76991118D-01	4.71238892D-01	2.12057504D 03	7.96393738D 03	1.41371669D 02

AFTER STEP NO. 672 DT = 0.5938211oD-05 THE TIME IS 0.24551076D-02

I	POSITION	VELOCITY	DENSITY	PRESSURE	ENERGY	AVG PRESS	AVG VELOC	CELL VOLUME	ENTROPY	THERAC	GAMMA
1	1.0000D-20	0.0000D 00	2.1399D 68	2.1399D 68	2.1399D 68	2.1399D 68	0.0000D 00	2.1399D 68	2.1399D 68	**********	**********
2	2.5190D-01	1.0940D 01	2.1612D-01	5.4614D 09	8.2217D 09	5.4814D 09	1.0940D 01	1.9935D-01	7.3812D 10	1.0000	1.6667
3	5.0400D-01	1.8226D 01	2.0990D-01	5.4719D 09	8.2075D 09	5.4719D 09	1.8226D 01	5.9867D-01	7.3812D 10	1.0000	1.6667
4	7.5641D-01	1.9777D 01	2.0956D-01	5.4568D 09	8.1849D 09	5.4568D 09	1.9777D 01	9.9944D-01	7.3812D 10	1.0000	1.6667
5	1.1554D 00	1.2491D 01	8.8496D-02	5.4386D 09	5.4386D 09	5.4386D 09	1.2491D 01	2.3962D 00	6.9444D 11	1.0000	2.0000
6	1.5063D 00	-6.8789D-01	8.8340D-02	5.4194D 09	5.4194D 09	5.4194D 09	-6.8789D-01	2.9339D 00	6.9444D 11	1.0000	2.0000
7	2.0659D 00	-2.1210D 00	1.0027D 00	5.2433D 09	9.6048D 06	5.2433D 09	-2.1210D 00	6.2799D 00	1.0000D 11	1.0000	0.5000
8	3.2125D 00	-1.0948D 01	1.0024D 00	4.8479D 09	7.5922D 06	4.8479D 09	-1.0948D 01	1.9014D 01	1.0000D 11	1.0000	0.5000
9	4.5375D 00	-2.6357D 01	1.0020D 00	4.4289D 09	5.7897D 06	4.4289D 09	-2.6357D 01	3.2260D 01	1.0000D 11	1.0000	0.5000
10	5.9449D 00	-4.5146D 01	1.0017D 00	4.0918D 09	4.5664D 06	4.0918D 09	-4.5146D 01	4.6348D 01	1.0000D 11	0.9998	0.5000
11	7.4131D 00	-6.5527D 01	1.0015D 00	3.8155D 09	3.7036D 06	3.8155D 09	-6.5527D 01	6.1611D 01	1.0000D 11	0.9995	0.5000
12	8.9389D 00	-8.6519D 01	1.0013D 00	3.5799D 09	3.0689D 06	3.5799D 09	-8.6519D 01	7.8384D 01	1.0000D 11	0.9990	0.5000
13	1.0525D 01	-1.0752D 02	1.0011D 00	3.3726D 09	2.5618D 06	3.3726D 09	-1.0752D 02	9.7000D 01	1.0000D 11	0.9981	0.5000
14	1.2177D 01	-1.2813D 02	1.0010D 00	3.1858D 09	2.1623D 06	3.1858D 09	-1.2813D 02	1.1779D 02	1.0000D 11	0.9967	0.5000
15	1.3899D 01	-1.4804D 02	1.0009D 00	3.0144D 09	1.8355D 06	3.0144D 09	-1.4804D 02	1.4110D 02	1.0000D 11	0.9947	0.5000
16	1.5698D 01	-1.6698D 02	1.0008D 00	2.8551D 09	1.5638D 06	2.8551D 09	-1.6698D 02	1.6726D 02	1.0000D 11	0.9919	0.5000
17	1.7579D 01	-1.8474D 02	1.0007D 00	2.7054D 09	1.3356D 06	2.7054D 09	-1.8474D 02	1.9660D 02	1.0000D 11	0.9883	0.5000
18	1.9546D 01	-2.0113D 02	1.0007D 00	2.5639D 09	1.1422D 06	2.5639D 09	-2.0113D 02	2.2946D 02	1.0000D 11	0.9836	0.5000
19	2.1605D 01	-2.1597D 02	1.0006D 00	2.4291D 09	9.7736D 05	2.4291D 09	-2.1597D 02	2.6618D 02	1.0000D 11	0.9776	0.5000
20	2.3760D 01	-2.2910D 02	1.0005D 00	2.3003D 09	8.3631D 05	2.3003D 09	-2.2910D 02	3.0709D 02	1.0000D 11	0.9702	0.5000
21	2.6014D 01	-2.4037D 02	1.0005D 00	2.1768D 09	7.1521D 05	2.1768D 09	-2.4037D 02	3.5252D 02	1.0000D 11	0.9613	0.5000
22	2.6528D 01	-2.4204D 02	7.8032D 00	2.0135D 09	7.7119D 05	2.0135D 09	-2.4204D 02	8.4892D 01	3.5806D 10	0.7056	0.5000
23	2.7463D 01	-2.4229D 02	7.8023D 00	1.7295D 09	5.7364D 05	1.7295D 09	-2.4229D 02	1.5848D 02	3.5806D 10	0.6012	0.5000
24	2.8662D 01	-2.3852D 02	7.8014D 00	1.3234D 09	3.7983D 05	1.3234D 09	-2.3852D 02	2.1149D 02	3.5806D 10	0.4068	0.5000
25	3.0069D 01	-2.3036D 02	7.8006D 00	8.4685D 08	2.5465D 05	8.4685D 08	-2.3036D 02	2.5959D 02	3.5806D 10	0.1590	0.5000
26	3.1650D 01	-2.1931D 02	7.8001D 00	3.2556D 08	1.9919D 05	3.2556D 08	-2.1931D 02	3.0642D 02	3.5806D 10	0.0115	0.5000
27	3.3357D 01	-1.0094D 03	7.6753D-02	5.3491D 07	1.3375D 08	5.3491D 07	-1.0094D 03	3.4873D 02	1.9460D 09	0.9998	1.4000
28	3.5058D 01	-9.1226D 02	7.5264D-02	5.2044D 07	1.3014D 08	5.2044D 07	-9.1226D 02	3.6565D 02	1.9460D 09	0.9997	1.4000
29	3.6733D 01	-6.3349D 02	7.4852D-02	5.1645D 07	1.2914D 08	5.1645D 07	-6.3349D 02	3.7774D 02	1.9460D 09	0.9998	1.4000
30	3.8380D 01	-3.1736D 02	7.4766D-02	5.1504D 07	1.2877D 08	5.1504D 07	-3.1736D 02	3.8857D 02	1.9460D 09	0.9999	1.4000
31	4.0000D 01	0.0000D 00	7.4652D-02	5.1452D 07	1.2863D 08	5.1452D 07	0.0000D 00	3.9895D 02	1.9460D 09	1.0000	1.4000

TIMINGS AT CYCLE 673 TIME = 2.4551D-03

REZONE	TIMESTEP	CELL PRINT	LAYER PRNT	GRAPHICS	CHEMISTRY	DIFFUSION	CONDUCTION	ADINC
0.0000D 00	3.4428D-01	1.5585D 00	3.8070D-01	0.0000D 00	0.0000D 00	0.0000D 00	0.0000D 00	8.2243D 00

ADINC FREQUENCY COUNTERS (SINCE LAST CHECK) AT CYCLE 673
NO. CALLS = 672 NO. TIMESTEPS = 1 TOTAL NO. ITERATIONS = 4

LAYER BOUNDARY	INTER 1	INTER 2	INTER 3	INTER 4	INTER 5	INTER 6
INTERFACE POSITION	1.00000000D-20	7.56406400D-01	1.50625120D 00	2.60141810D 01	3.16495311D 01	4.00000000D 01
INTERFACE VELOCITY	0.00000000D 00	1.97766949D 01	-6.87894342D-01	-2.40371893D 02	-2.19306073D 02	0.00000000D 00
INTERFACE AREA	6.28318531D-20	4.75264158D 00	9.46405542D 00	1.63451920D 02	1.98859869D 02	2.51327412D 02

	TOTALS	SHELL 1	SHELL 2	SHELL 3	SHELL 4	SHELL 5
THERMAL ERG	2.91492520D 11	1.47328742D 10	2.89321041D 10	3.35294075D 09	1.44740051D 08	2.44329861D 11
KINETIC ERG	2.87904796D 08	5.87069510D 01	3.33212377D 01	3.57971696D 07	2.19113482D 04	3.29940517D 07
TOTAL ERG	2.91780425D 11	1.47328743D 10	2.89321041D 10	3.38873792D 09	3.63853534D 08	2.44362855D 11
VOL AVG RHO	2.03454375D 00	2.09734974D-01	8.84099274D-02	1.00078755D 00	7.80107520D 00	7.52122010D-02
VOL AVG PRE	1.39263513D 09	5.46459115D 09	5.42800102D 09	2.74630512D 09	1.02313809D 09	5.19951039D 07
VOL AVG GAM	8.38555597D-01	1.66670000D 00	2.00000000D 00	5.00000000D-01	5.00000000D-01	1.40000000D 00
VOL AVG ENT	5.09168667D 10	7.38122794D 10	6.94444444D 11	1.00000107D 11	3.58057422D 10	1.94601532D 09
VOL AVG RHOC	2.00569964D 00	0.00000000D 00	0.00000000D 00	1.00000000D 00	7.80000000D 00	0.00000000D 00
LAYER VOLUME	5.02654825D 03	1.79746425D 00	5.33015818D 00	2.11890629D 03	1.02087689D 03	1.87963745D 03
LAYER MASS	1.02267323D 04	3.76991118D-01	4.71238898D-01	2.12057504D 03	7.96393738D 03	1.41371669D 02

AFTER STEP NO. 673 DT = 0.65320328D-05 THE TIME IS 0.24610458D-02

I	POSITION	VELOCITY	DENSITY	PRESSURE	ENERGY	AVG PRESS	AVG VELOC	CELL VOLUME	ENTROPY	THERAC	GAMMA
1	1.0000D-20	0.0000D 00	2.1399D 68	2.1399D 68	2.1399D 68	2.1399D 68	0.0000D 00	2.1399D 68	2.1399D 68	**********	**********
2	2.5586D-01	6.6644D 02	2.0367D-01	5.2038D 09	7.8054D 09	5.2038D 09	6.6644D 02	2.0566D-01	7.3812D 10	1.0000	1.6667
3	5.1189D-01	1.3283D 03	2.0349D-01	5.1962D 09	7.7941D 09	5.1962D 09	1.3283D 03	6.1753D-01	7.3812D 10	1.0000	1.6667
4	7.6818D-01	1.9832D 03	2.0321D-01	5.1841D 09	7.7760D 09	5.1841D 09	1.9832D 03	1.0307D 00	7.3812D 10	1.0000	1.6667
5	1.1715D 00	2.7189D 03	8.6277D-02	5.1693D 09	5.1695D 09	5.1693D 09	2.7189D 03	2.4579D 00	6.9444D 11	0.9999	2.0000
6	1.5265D 00	3.4059D 03	8.6147D-02	5.1537D 09	5.1542D 09	5.1537D 09	3.4059D 03	3.0086D 00	6.9444D 11	0.9999	2.0000
7	2.0808D 00	2.5105D 03	1.0025D 00	5.0086D 09	1.2555D 07	5.0086D 09	2.5105D 03	6.2814D 00	1.0000D 11	0.6668	0.5000
8	3.2223D 00	1.6428D 03	1.0022D 00	4.6820D 09	8.8074D 06	4.6820D 09	1.6428D 03	1.9017D 01	1.0000D 11	0.7765	0.5000
9	4.5445D 00	1.1796D 03	1.0019D 00	4.3347D 09	6.3693D 06	4.3347D 09	1.1796D 03	3.2263D 01	1.0000D 11	0.8522	0.5000
10	5.9503D 00	9.0720D 02	1.0016D 00	4.0531D 09	4.9637D 06	4.0531D 09	9.0720D 02	4.6350D 01	1.0000D 11	0.8940	0.5000
11	7.4174D 00	7.2686D 02	1.0015D 00	3.8201D 09	4.0417D 06	3.8201D 09	7.2686D 02	6.1611D 01	1.0000D 11	0.9193	0.5000
12	8.9424D 00	5.9627D 02	1.0013D 00	3.6189D 09	3.3740D 06	3.6189D 09	5.9627D 02	7.8381D 01	1.0000D 11	0.9362	0.5000
13	1.0528D 01	4.9528D 02	1.0012D 00	3.4390D 09	2.8579D 06	3.4390D 09	4.9528D 02	9.6995D 01	1.0000D 11	0.9486	0.5000
14	1.2179D 01	4.1336D 02	1.0011D 00	3.2741D 09	2.4413D 06	3.2741D 09	4.1336D 02	1.1779D 02	1.0000D 11	0.9582	0.5000
15	1.3901D 01	3.4457D 02	1.0010D 00	3.1198D 09	2.0951D 06	3.1198D 09	3.4457D 02	1.4109D 02	1.0000D 11	0.9660	0.5000
16	1.5700D 01	2.8541D 02	1.0009D 00	2.9734D 09	1.8015D 06	2.9734D 09	2.8541D 02	1.6725D 02	1.0000D 11	0.9727	0.5000
17	1.7580D 01	2.3371D 02	1.0008D 00	2.8331D 09	1.5491D 06	2.8331D 09	2.3371D 02	1.9659D 02	1.0000D 11	0.9784	0.5000
18	1.9547D 01	1.8811D 02	1.0007D 00	2.6973D 09	1.3302D 06	2.6973D 09	1.8811D 02	2.2945D 02	1.0000D 11	0.9834	0.5000
19	2.1606D 01	1.4776D 02	1.0007D 00	2.5652D 09	1.1392D 06	2.5652D 09	1.4776D 02	2.6616D 02	1.0000D 11	0.9877	0.5000
20	2.3760D 01	1.1211D 02	1.0006D 00	2.4361D 09	9.7211D 05	2.4361D 09	1.1211D 02	3.0707D 02	1.0000D 11	0.9913	0.5000
21	2.6015D 01	8.0804D 01	1.0005D 00	2.3093D 09	8.2563D 05	2.3093D 09	8.0804D 01	3.5249D 02	1.0000D 11	0.9943	0.5000
22	2.6529D 01	7.4803D 01	7.8036D 00	2.1381D 09	6.7519D 05	2.1381D 09	7.4803D 01	8.4887D 01	3.5806D 10	0.9650	0.5000
23	2.7463D 01	6.6223D 01	7.8026D 00	1.8389D 09	4.3392D 05	1.8389D 09	6.6223D 01	1.5848D 02	3.5806D 10	0.9553	0.5000
24	2.8663D 01	5.8862D 01	7.8015D 00	1.4083D 09	2.0146D 05	1.4083D 09	5.8862D 01	2.1149D 02	3.5806D 10	0.9243	0.5000
25	3.0070D 01	5.3926D 01	7.8006D 00	9.0089D 08	6.1118D 04	9.0089D 08	5.3926D 01	2.5958D 02	3.5806D 10	0.7973	0.5000
26	3.1650D 01	5.0908D 01	7.8001D 00	3.4430D 08	1.3422D 04	3.4430D 08	5.0908D 01	3.0642D 02	3.5806D 10	0.2027	0.5000
27	3.3352D 01	-9.3120D 02	7.7022D-02	5.3754D 07	1.3440D 08	5.3754D 07	-9.3120D 02	3.4751D 02	1.9460D 09	0.9999	1.4000
28	3.5053D 01	-8.9081D 02	7.5265D-02	5.2045D 07	1.3014D 08	5.2045D 07	-8.9081D 02	3.6565D 02	1.9460D 09	0.9998	1.4000
29	3.6729D 01	-6.2596D 02	7.4791D-02	5.1587D 07	1.2899D 08	5.1587D 07	-6.2596D 02	3.7804D 02	1.9460D 09	0.9998	1.4000
30	3.8378D 01	-3.1453D 02	7.4628D-02	5.1429D 07	1.2858D 08	5.1429D 07	-3.1453D 02	3.8897D 02	1.9460D 09	0.9999	1.4000
31	4.0000D 01	0.0000D 00	7.4568D-02	5.1371D 07	1.2843D 08	5.1371D 07	0.0000D 00	3.9940D 02	1.9460D 09	1.0000	1.4000

TIMINGS AT CYCLE 674 TIME = 2.4610D-03

REZONE	TIMESTEP	CELL PRINT	LAYER PRNT	GRAPHICS	CHEMISTRY	DIFFUSION	CONDUCTION	ADINC
0.0000D 00	3.4479D-01	1.6238D 00	3.9653D-01	0.0000D 00	0.0000D 00	0.0000D 00	0.0000D 00	8.2381D 00

ADINC FREQUENCY COUNTERS (SINCE LAST CHECK) AT CYCLE 674
NO. CALLS = 673 NO. TIMESTEPS = 1 TOTAL NO. ITERATIONS = 4

LAYER BOUNDARY	INTER 1	INTER 2	INTER 3	INTER 4	INTER 5	INTER 6
INTERFACE POSITION	1.0000000D-20	7.68182820D-01	1.52647599D 00	2.66146608D 01	3.16498334D 01	4.0000000D 01
INTERFACE VELOCITY	0.0000000D 00	1.98315939D 03	3.40587240D 03	8.08361150 01	5.0907800D 01	0.0000000D 00
INTERFACE AREA	6.28318531D-20	4.82663501D 00	9.59113153D 00	1.63454935D 02	1.9886176D 02	2.51327412D 02

	TOTALS	SHELL 1	SHELL 2	SHELL 3	SHELL 4	SHELL 5
THERMAL ERG	2.9079260D 11	1.4432484 7D 10	2.82107658D 10	3.63992265D 09	1.73865221D 08	2.44335565D 11
KINETIC ERG	2.6676190 5D 08	4.3062471 7D 05	1.94090353D 06	2.1965000D 08	1.4902241 1D 07	2.9938065 2D 07
TOTAL ERG	2.9105936 5D 11	1.4432915 3D 10	2.82127607D 10	3.8595727 4D 09	1.8866742 2D 08	2.4433655 3D 11
VOL AVG RHO	2.0345437 5D 00	2.0335369 4D-01	8.62057019D-02	1.0008415 3D 00	7.8012151 5D 00	7.5214606 5D-02
VOL AVG PRE	1.4503515 9D 09	5.1993005 7D 09	5.16071334D 09	2.8528489 3D 09	1.0874105 0D 09	5.1997980 8D 07
VOL AVG GAM	8.3859859 6D-01	1.6667000 0D 00	2.0000000 0D 00	5.0000000 0D-01	5.0000000 0D-01	1.4000000 0D 00
VOL AVG ENT	5.0934097 0D 10	7.3812279 4D 10	6.9444444 4D 11	1.0000000 7D 11	3.5857422 5D 10	1.9460153 2D 09
VOL AVG RHOC	2.0056484 9D 00	0.0000000 0D 00	0.0000000 0D 00	1.0000000 0D 00	7.8000000 0D 00	0.0000000 0D 00
LAYER VOLUME	5.6265482 5D 03	1.8533690 4D 00	5.46044697D 00	2.1187928 2D 03	1.0228585 7D 03	1.8795773 3D 03
LAYER MASS	1.0226732 3D 04	3.7699111 8D-01	4.7123889 8D-01	2.1205750 0D 03	7.9639372 0D 03	1.4137160 9D 02

AFTER STEP NO. 675 DT = 0.74782260D-05 THE TIME IS 0.24747631D-02

I	POSITION	VELOCITY	DENSITY	PRESSURE	ENERGY	AVG PRESS	AVG VELOC	CELL VOLUME	ENTROPY	THFRAC	GAMMA
1	1.0000D-20	0.0000D 00	2.1399D 68	2.1399D 68	2.1399D 68	2.1399D 68	0.0000D 00	2.1399D 68	2.1399D 68	**********	**********
2	2.7581D-01	1.6711D 03	1.7527D-01	4.0516D 09	6.0774D 09	4.0516D 09	1.6711D 03	2.3899D-01	7.3812D 10	1.0000	1.6667
3	5.5175D-01	3.3397D 03	1.7517D-01	4.0476D 09	6.0719D 09	4.0476D 09	3.3397D 03	7.1739D-01	7.3812D 10	0.9999	1.6667
4	8.2787D-01	5.0042D 03	1.7500D-01	4.0412D 09	6.0633D 09	4.0412D 09	5.0042D 03	1.1968D 00	7.3812D 10	0.9997	1.6667
5	1.2534D 00	6.8635D 03	7.6211D-02	4.0334D 09	4.0349D 09	4.0334D 09	6.8635D 03	2.7825D 00	6.9444D 11	0.9996	2.0000
6	1.6293D 00	8.6206D 03	7.6133D-02	4.0252D 09	4.0276D 09	4.0252D 09	8.6206D 03	3.4043D 00	6.9444D 11	0.9994	2.0000
7	2.1578D 00	6.4891D 03	1.0016D 00	3.9445D 09	3.1564D 07	3.9445D 09	6.4891D 03	6.2874D 00	1.0000D 11	0.1296	0.5000
8	3.2733D 00	4.3088D 03	1.0014D 00	3.7524D 09	1.6921D 07	3.7524D 09	4.3088D 03	1.9032D 01	1.0000D 11	0.2081	0.5000
9	4.5815D 00	3.1296D 03	1.0013D 00	3.5403D 09	9.5131D 06	3.5403D 09	3.1296D 03	3.2283D 01	1.0000D 11	0.3109	0.5000
10	5.9792D 00	2.4506D 03	1.0011D 00	3.3665D 09	6.3103D 06	3.3665D 09	2.4506D 03	4.6373D 01	1.0000D 11	0.4030	0.5000
11	7.4412D 00	2.0192D 03	1.0010D 00	3.2221D 09	4.6744D 06	3.2221D 09	2.0192D 03	6.1637D 01	1.0000D 11	0.4770	0.5000
12	8.9627D 00	1.7233D 03	1.0010D 00	3.0967D 09	3.7043D 06	3.0967D 09	1.7233D 03	7.8409D 01	1.0000D 11	0.5343	0.5000
13	1.0546D 01	1.5081D 03	1.0009D 00	2.9831D 09	3.0605D 06	2.9831D 09	1.5081D 03	9.7024D 01	1.0000D 11	0.5782	0.5000
14	1.2195D 01	1.3445D 03	1.0008D 00	2.8768D 09	2.5957D 06	2.8768D 09	1.3445D 03	1.1782D 02	1.0000D 11	0.6114	0.5000
15	1.3915D 01	1.2157D 03	1.0008D 00	2.7746D 09	2.2376D 06	2.7746D 09	1.2157D 03	1.4112D 02	1.0000D 11	0.6363	0.5000
16	1.5712D 01	1.1112D 03	1.0007D 00	2.6741D 09	1.9477D 06	2.6741D 09	1.1112D 03	1.6728D 02	1.0000D 11	0.6544	0.5000
17	1.7592D 01	1.0245D 03	1.0007D 00	2.5737D 09	1.7039D 06	2.5737D 09	1.0245D 03	1.9662D 02	1.0000D 11	0.6669	0.5000
18	1.9558D 01	9.5097D 02	1.0006D 00	2.4722D 09	1.4930D 06	2.4722D 09	9.5097D 02	2.2948D 02	1.0000D 11	0.6746	0.5000
19	2.1616D 01	8.8767D 02	1.0006D 00	2.3685D 09	1.3069D 06	2.3685D 09	8.8767D 02	2.6619D 02	1.0000D 11	0.6778	0.5000
20	2.3770D 01	8.3242D 02	1.0005D 00	2.2622D 09	1.1404D 06	2.2622D 09	8.3242D 02	3.0789D 02	1.0000D 11	0.6767	0.5000
21	2.6023D 01	7.8368D 02	1.0005D 00	2.1527D 09	9.9054D 05	2.1527D 09	7.8368D 02	3.5252D 02	1.0000D 11	0.6713	0.5000
22	2.6537D 01	7.7317D 02	7.8631D 00	1.9976D 09	2.8951D 06	1.9976D 09	7.7317D 02	8.4892D 01	3.5806D 10	0.1835	0.5000
23	2.7471D 01	7.5299D 02	7.8023D 00	1.7241D 09	2.6121D 06	1.7241D 09	7.5299D 02	1.5848D 02	3.5806D 10	0.1308	0.5000
24	2.8670D 01	7.2597D 02	7.8014D 00	1.3255D 09	2.2865D 06	1.3255D 09	7.2597D 02	2.1149D 02	3.5806D 10	0.0679	0.5000
25	3.0077D 01	6.9409D 02	7.8006D 00	8.5085D 08	2.0052D 06	8.5085D 08	6.9409D 02	2.5959D 02	3.5806D 10	0.0205	0.5000
26	3.1657D 01	6.5975D 02	7.8001D 00	3.2783D 08	1.7871D 06	3.2783D 08	6.5975D 02	3.0642D 02	3.5806D 10	0.0013	0.5000
27	3.3341D 01	-6.9497D 02	7.7824D-02	5.4539D 07	1.3637D 08	5.4539D 07	-6.9497D 02	3.4393D 02	1.9860D 09	0.9999	1.4000
28	3.5041D 01	-8.2628D 02	7.5341D-02	5.2118D 07	1.3032D 08	5.2118D 07	-8.2628D 02	3.6528D 02	1.9860D 09	0.9998	1.4000
29	3.6721D 01	-6.0450D 02	7.4669D-02	5.1469D 07	1.2869D 08	5.1469D 07	-6.0450D 02	3.7866D 02	1.9860D 09	0.9998	1.4000
30	3.8374D 01	-3.0673D 02	7.4454D-02	5.1261D 07	1.2816D 08	5.1261D 07	-3.0673D 02	3.8088D 02	1.9860D 09	0.9999	1.4000
31	4.0000D 01	0.0000D 00	7.4377D-02	5.1188D 07	1.2797D 08	5.1188D 07	0.0000D 00	4.0042D 02	1.9860D 09	1.0000	1.4000

TIMINGS AT CYCLE 676 TIME = 2.4748D-03

REZONE	TIMESTEP	CELL PRINT	LAYER PRNT	GRAPHICS	CHEMISTRY	DIFFUSION	CONDUCTION	ADINC
0.0000D 00	3.4581D-01	1.6889D 00	4.1234D-01	0.0000D 00	0.0000D 00	0.0000D 00	0.0000D 00	8.2686D 00

ADINC FREQUENCY COUNTERS (SINCE LAST CHECK) AT CYCLE 676
NO. CALLS = 675 NO. TIMESTEPS = 2 TOTAL NO. ITERATIONS = 9

LAYER BOUNDARY	INTER 1	INTER 2	INTER 3	INTER 4	INTER 5	INTER 6
INTERFACE POSITION	1.0000000000D-20	8.2787007730-01	1.629325190 00	2.602311120 01	3.165687420 01	4.000000000D 01
INTERFACE VELOCITY	0.0000000000 00	5.004166750 03	8.620637350 03	7.836773340 02	0.597406550 02	0.000000000D 00
INTERFACE AREA	0.283185310-20	5.201661080 00	1.023735210 01	1.635080300 02	1.989060070 02	2.513274120 02

	TOTALS	SHELL 1	SHELL 2	SHELL 3	SHELL 4	SHELL 5
THERMAL ERG	2.850823140 11	1.366197120 10	2.492591660 10	2.533245040 09	1.434660520 08	2.944177150 11
KINETIC ERG	4.243434190 09	2.733689760 06	1.238924160 07	2.134813620 09	2.067990520 09	2.550711930 07
TOTAL ERG	2.893257490 11	1.366470490 10	2.493830580 10	4.668058860 09	2.211457040 09	2.944432220 11
VOL AVG RHO	2.034543750 00	1.759882000-01	7.616797080-02	1.000667650 00	7.861071410 00	7.527068370-02
VOL AVG PRE	1.314721110 09	4.944500900 09	4.028861990 09	2.563584500 09	1.923117730 09	5.205424420 07
VOL AVG GAM	8.386323150-01	1.666700000 00	2.000000000 00	5.000000000-01	5.000060000-01	1.400000000 00
VOL AVG ENT	5.104480770 10	7.381227940 10	6.944444440 11	1.000001070 11	3.586574220 10	1.946015320 09
VOL AVG RHOC	2.005749660 00	0.000000000 00	0.000000000 00	1.000000000 00	7.861000000 00	0.000000000 00
LAYER VOLUME	5.026548250 03	2.153149770 00	0.186838020 00	2.119153840 03	1.020873580 03	1.878177030 03
LAYER MASS	1.022673230 04	3.769911180-01	4.712388980-01	2.120575040 03	7.963937380 03	1.041371660 02

AFTER STEP NO. 681 DT = 0.43175700D-05 THE TIME IS 0.25039058D-02

I	POSITION	VELOCITY	DENSITY	PRESSURE	ENERGY	AVG PRESS	AVG VELOC	CELL VOLUME	ENTROPY	THFRAC	GAMMA
1	1.00000-20	0.00000 00	2.13990 68	2.13990 68	2.13990 68	2.13990 68	0.00000 00	2.13990 68	2.13990 68	**********	
2	3.54440-01	3.48150 03	1.06130-01	1.75590 09	2.63440 09	1.75590 09	3.48150 03	3.94680-01	7.38120 10	0.9998	1.6667
3	7.09210-01	6.97140 03	1.06000-01	1.75240 09	2.63050 09	1.75240 09	6.97140 03	1.18550 00	7.38120 10	0.9992	1.6667
4	1.06450 00	1.04730 04	1.05880-01	1.74690 09	2.62480 09	1.74690 09	1.04730 04	1.97950 00	7.38120 10	0.9982	1.6667
5	1.57530 00	1.41330 04	5.00580-02	1.74020 09	1.74440 09	1.74020 09	1.41330 04	4.23620 00	6.94440 11	0.9976	2.0000
6	2.03290 00	1.76490 04	4.99640-02	1.73360 09	1.74030 09	1.73360 09	1.76490 04	5.18740 00	6.94440 11	0.9962	2.0000
7	2.47720 00	1.43940 04	1.00030 00	1.66580 09	1.26160 08	1.66580 09	1.43940 04	6.29540 00	1.00000 11	0.0024	0.5000
8	3.49310 00	1.01530 04	1.00020 00	1.46630 09	7.12100 07	1.46630 09	1.01530 04	1.90550 01	1.00000 11	0.0030	0.5000
9	4.74230 00	7.46900 03	1.00010 00	1.20140 09	3.71670 07	1.20140 09	7.46900 03	3.23190 01	1.00000 11	0.0031	0.5000
10	6.10460 00	5.86560 03	1.00010 00	9.67800 08	2.14010 07	9.67800 08	5.86560 03	4.64210 01	1.00000 11	0.0028	0.5000
11	7.54350 00	4.70430 03	1.00010 00	7.75620 08	1.35350 07	7.75620 08	4.70430 03	6.16970 01	1.00000 11	0.0023	0.5000
12	9.04910 00	3.92770 03	1.00000 00	6.17930 08	9.17790 06	6.17930 08	3.92770 03	7.84810 01	1.00000 11	0.0017	0.5000
13	1.06210 01	3.35170 03	1.00000 00	4.87760 08	6.54770 06	4.87760 08	3.35170 03	9.71080 01	1.00000 11	0.0012	0.5000
14	1.22610 01	2.90750 03	1.00000 00	3.79980 08	4.85100 06	3.79980 08	2.90750 03	1.17910 02	1.00000 11	0.0008	0.5000
15	1.39740 01	2.55420 03	1.00000 00	2.90950 08	3.69880 06	2.90950 08	2.55420 03	1.41230 02	1.00000 11	0.0004	0.5000
16	1.57660 01	2.26630 03	1.00000 00	2.18080 08	2.88440 06	2.18080 08	2.26630 03	1.67400 02	1.00000 11	0.0002	0.5000
17	1.76410 01	2.02710 03	1.00000 00	1.59470 08	2.29000 06	1.59470 08	2.02710 03	1.96750 02	1.00000 11	0.0001	0.5000
18	1.96030 01	1.82540 03	1.00000 00	1.13640 08	1.84510 06	1.13640 08	1.82540 03	2.29620 02	1.00000 11	0.0001	0.5000
19	2.16580 01	1.65700 03	1.00000 00	7.94510 07	1.50500 06	7.94510 07	1.65300 03	2.66340 02	1.00000 11	0.0000	0.5000
20	2.38090 01	1.50420 03	1.00000 00	5.59410 07	1.24050 06	5.59410 07	1.50420 03	3.07250 02	1.00000 11	0.0000	0.5000
21	2.60600 01	1.37470 03	1.00000 00	4.23130 07	1.03190 06	4.23130 07	1.37470 03	3.52680 02	1.00000 11	0.0000	0.5000
22	2.85740 01	1.34830 03	7.80000 00	3.62470 07	7.22790 06	3.62470 07	1.34830 03	8.49260 01	3.58060 10	0.0000	0.5000
23	2.75070 01	1.30260 03	7.80000 00	2.99510 07	6.84730 06	2.99510 07	1.30260 03	1.58530 02	3.58060 10	0.0000	0.5000
24	2.87050 01	1.24830 03	7.80000 00	2.93880 07	6.33880 06	2.93880 07	1.24830 03	2.11530 02	3.58060 10	0.0000	0.5000
25	3.01100 01	1.19010 03	7.80000 00	3.66500 07	5.79080 06	3.66500 07	1.19010 03	2.59610 02	3.58060 10	0.0000	0.5000
26	3.16880 01	1.13090 03	7.80000 00	4.92450 07	5.24540 06	4.92450 07	1.13090 03	3.06420 02	3.58060 10	0.0000	0.5000
27	3.33330 01	3.55830 01	7.96030-02	5.63320 07	1.40850 08	5.63320 07	3.55830 01	3.36080 02	1.94600 09	0.9999	1.4000
28	3.50210 01	-5.89120 02	7.59210-02	5.26810 07	1.31710 08	5.26810 07	-5.89120 02	3.62490 02	1.94600 09	0.9999	1.4000
29	3.67050 01	-5.31680 02	7.45360-02	5.13410 07	1.28360 08	5.13410 07	-5.31680 02	3.79340 02	1.94600 09	0.9999	1.4000
30	3.83650 01	-2.82720 02	7.41240-02	5.09440 07	1.27370 08	5.09440 07	-2.82720 02	3.91620 02	1.94600 09	0.9999	1.4000
31	4.00000 01	0.00000 00	7.39970-02	5.08210 07	1.27050 08	5.08210 07	0.00000 00	4.02480 02	1.94600 09	1.0000	1.4000

TIMINGS AT CYCLE 681 TIME = 2.5039D-03

REZONE	TIMESTEP	CELL PRINT	LAYER PRNT	GRAPHICS	CHEMISTRY	DIFFUSION	CONDUCTION	ADINC
0.00000 00	3.48370-01	1.75410 03	4.28160-01	0.00000 00	0.00000 00	0.00000 00	0.00000 00	8.3513D 00

ADINC FREQUENCY COUNTERS (SINCE LAST CHECK) AT CYCLE 681
NO. CALLS = 680 NO. TIMESTEPS = 5 TOTAL NO. ITERATIONS = 25

LAYER BOUNDARY	INTER 1	INTER 2	INTER 3	INTER 4	INTER 5	INTER 6
INTERFACE POSITION	1.00000000D-20	1.06446099D 00	2.03290372D 00	2.60599993D 01	3.16879080D 01	4.00000000D 01
INTERFACE VELOCITY	0.00000000D 00	1.04726599D 04	1.76486079D 04	1.37474113D 03	1.13085099D 03	0.00000000D 00
INTERFACE AREA	6.28318531D-20	6.68820002D 00	1.27731108D 01	1.63739805D 02	1.99130998D 02	2.51327412D 02

	TOTALS	SHELL 1	SHELL 2	SHELL 3	SHELL 4	SHELL 5
THERMAL ERG	2.70494821D 11	9.34211937D 09	1.63645367D 10	1.72592733D 07	4.20309786D 03	2.44770902D 11
KINETIC ERG	1.63504317D 10	1.19482623D 07	5.22659421D 07	1.01170482D 10	6.15084804D 09	1.83207167D 07
TOTAL ERG	2.86945253D 11	9.35406820D 09	1.64168026D 10	1.01343675D 10	6.15085225D 09	2.44789222D 11
VOL AVG RHO	2.03454375D 00	1.05966466D-01	5.00062960D-02	1.00001353D 00	7.80000117D 00	7.55190063D-02
VOL AVG PRE	1.30942610D 08	1.74971464D 07	1.73654992D 08	2.35334544D 08	3.78516977D 07	5.23014416D 07
VOL AVG GAM	8.38118930D-01	1.66670000D 00	2.00000000D 00	5.00000000D-01	5.00000000D-01	1.40000000D 00
VOL AVG ENT	5.15389462D 10	7.38122794D 10	6.94444444D 11	1.00000107D 11	3.58057422D 10	1.94601532D 09
VOL AVG RHOC	2.00624465D 00	0.00000000D 00	0.00000000D 00	1.00000000D 00	7.80000000D 00	0.00000000D 00
LAYER VOLUME	5.02654925D 03	3.55966101D 00	9.42359126D 00	2.12054635D 03	1.02101746D 03	1.87200119D 03
LAYER MASS	1.02267323D 04	3.76991118D-01	4.71238898D-01	2.12057504D 03	7.96393738D 03	1.01371669D 02

AFTER STEP NO. 700 DT = 0.32136741D-05 THE TIME IS 0.25750731D-02

I	POSITION	VELOCITY	DENSITY	PRESSURE	ENERGY	AVG PRESS	AVG VELOC	CELL VOLUME	ENTROPY	THFRAC	GAMMA
1	1.00000D-20	0.0000D 00	2.13990 68	2.13990 68	2.1399D 68	2.1399D 68	0.0000D 00	2.1399D 68	2.1399D 68	**********	**********
2	6.04940D-01	3.2424D 03	3.6434D-02	2.9553D 08	4.4346D 08	2.9553D 08	3.2424D 03	1.1497D 00	7.3812D 10	0.9996	1.6667
3	1.2096D 00	6.5073D 03	3.6455D-02	2.9581D 08	4.4431D 08	2.9581D 08	6.5073D 03	3.4471D 00	7.3812D 10	0.9986	1.6667
4	1.8144D 00	9.7968D 03	3.6483D-02	2.9619D 08	4.4567D 08	2.9619D 08	9.7968D 03	5.7407D 00	7.3812D 10	0.9968	1.6667
5	2.5606D 00	1.2729D 04	2.0667D-02	2.9661D 08	2.9803D 08	2.9661D 08	1.2729D 04	1.0261D 01	6.9444D 11	0.9952	2.0000
6	3.2474D 00	1.5614D 04	2.0683D-02	2.9709D 08	2.9926D 08	2.9709D 08	1.5614D 04	1.2531D 01	6.9444D 11	0.9927	2.0000
7	3.5426D 00	1.4295D 04	1.0000D 00	3.0357D 08	1.1140D 08	3.0357D 08	1.4295D 04	6.2971D 00	1.0000D 11	0.0000	0.5000
8	4.3147D 00	1.1712D 04	1.0000D 00	3.1768D 08	8.2917D 07	3.1768D 08	1.1712D 04	1.9059D 01	1.0000D 11	0.0000	0.5000
9	5.3764D 00	9.3849D 03	1.0000D 00	3.2386D 08	5.4306D 07	3.2386D 08	9.3849D 03	3.2323D 01	1.0000D 11	0.0000	0.5000
10	6.6093D 00	7.6271D 03	1.0000D 00	3.1954D 08	3.5415D 07	3.1954D 08	7.6271D 03	4.6425D 01	1.0000D 11	0.0001	0.5000
11	7.9575D 00	6.3314D 03	1.0000D 00	3.0972D 08	2.3941D 07	3.0972D 08	6.3314D 03	6.1700D 01	1.0000D 11	0.0001	0.5000
12	9.3971D 00	5.3598D 03	1.0000D 00	2.9779D 08	1.6853D 07	2.9779D 08	5.3598D 03	7.8483D 01	1.0000D 11	0.0001	0.5000
13	1.0919D 01	4.6124D 03	1.0000D 00	2.8534D 08	1.2292D 07	2.8534D 08	4.6124D 03	9.7109D 01	1.0000D 11	0.0001	0.5000
14	1.2520D 01	4.0216D 03	1.0000D 00	2.7307D 08	9.2321D 06	2.7307D 08	4.0216D 03	1.1791D 02	1.0000D 11	0.0001	0.5000
15	1.4202D 01	3.5450D 03	1.0000D 00	2.6126D 08	7.1013D 06	2.6126D 08	3.5450D 03	1.4123D 02	1.0000D 11	0.0002	0.5000
16	1.5968D 01	3.1527D 03	1.0000D 00	2.5001D 08	5.5701D 06	2.5001D 08	3.1527D 03	1.6740D 02	1.0000D 11	0.0002	0.5000
17	1.7822D 01	2.8248D 03	1.0000D 00	2.3932D 08	4.4494D 06	2.3932D 08	2.8248D 03	1.9675D 02	1.0000D 11	0.0002	0.5000
18	1.9766D 01	2.5466D 03	1.0000D 00	2.2920D 08	3.5883D 06	2.2920D 08	2.5466D 03	2.2961D 02	1.0000D 11	0.0002	0.5000
19	2.1806D 01	2.3086D 03	1.0000D 00	2.1962D 08	2.9335D 06	2.1962D 08	2.3086D 03	2.6634D 02	1.0000D 11	0.0002	0.5000
20	2.3943D 01	2.1025D 03	1.0000D 00	2.1054D 08	2.4223D 06	2.1054D 08	2.1025D 03	3.0725D 02	1.0000D 11	0.0003	0.5000
21	2.6183D 01	1.9226D 03	1.0000D 00	2.0194D 08	2.0177D 06	2.0194D 08	1.9226D 03	3.5268D 02	1.0000D 11	0.0003	0.5000
22	2.6694D 01	1.8858D 03	7.8000D 00	1.9375D 08	1.4140D 07	1.9375D 08	1.8858D 03	8.4926D 01	3.5806D 10	0.0000	0.5000
23	2.7623D 01	1.8224D 03	7.8000D 00	1.7135D 08	1.3400D 07	1.7135D 08	1.8224D 03	1.5853D 02	3.5806D 10	0.0000	0.5000
24	2.8816D 01	1.7469D 03	7.8000D 00	1.4372D 08	1.2411D 07	1.4372D 08	1.7469D 03	2.1153D 02	3.5806D 10	0.0000	0.5000
25	3.0216D 01	1.6660D 03	7.8000D 00	1.1139D 08	1.1344D 07	1.1139D 08	1.6660D 03	2.5961D 02	3.5806D 10	0.0000	0.5000
26	3.1789D 01	1.5835D 03	7.8000D 00	7.5999D 07	1.0282D 07	7.5999D 07	1.5835D 03	3.0642D 02	3.5806D 10	0.0000	0.5000
27	3.3406D 01	1.7313D 03	8.0804D-02	5.7485D 07	1.4382D 08	5.7485D 07	1.7313D 03	3.3125D 02	1.9460D 09	0.9992	1.4000
28	3.5025D 01	8.2225D 02	7.9676D-02	5.5771D 07	1.3950D 08	5.5771D 07	8.2225D 02	3.4802D 02	1.9460D 09	0.9995	1.4000
29	3.6683D 01	3.2224D 01	7.5896D-02	5.2464D 07	1.3117D 08	5.2464D 07	3.2224D 01	3.7352D 02	1.9460D 09	0.9999	1.4000
30	3.8350D 01	-1.1580D 02	7.3887D-02	5.0715D 07	1.2679D 08	5.0715D 07	-1.1580D 02	3.9288D 02	1.9460D 09	1.0000	1.4000
31	4.0000D 01	0.0000D 00	7.3324D-02	5.0175D 07	1.2544D 08	5.0175D 07	0.0000D 00	4.0617D 02	1.9460D 09	1.0000	1.4000

TIMINGS AT CYCLE 701 TIME = 2.5751D-03

REZONE	TIMESTEP	CELL PRINT	LAYER PRNT	GRAPHICS	CHEMISTRY	DIFFUSION	CONDUCTION	ADINC
0.0000D 00	3.5860D-01	2.0139D 00	4.9140D-01	0.0000D 00	0.0000D 00	0.0000D 00	0.0000D 00	8.6338D 00

ADINC FREQUENCY COUNTERS (SINCE LAST CHECK) AT CYCLE 701
NO. CALLS = 700 NO. TIMESTEPS = 5 TOTAL NO. ITERATIONS = 20

LAYER BOUNDARY	INTER 1	INTER 2	INTER 3	INTER 4	INTER 5	INTER 6
INTERFACE POSITION	1.00000000D-20	1.61398241D 00	3.24735967D 00	2.61828452D 01	3.17690050D 01	4.00000000D 01
INTERFACE VELOCITY	0.00000000D 00	9.79678650D 03	1.56142001D 04	1.92263756D 03	1.58353389D 03	0.00000000D 00
INTERFACE AREA	6.28318531D-20	1.13975876D 01	2.04037626D 01	1.64511668D 02	1.99736209D 02	2.51327412D 02

	TOTALS	SHELL 1	SHELL 2	SHELL 3	SHELL 4	SHELL 5
THERMAL ERG	2.57239900D 11	4.58942351D 09	6.76618346D 09	2.07675316D 06	1.67217077D 05	2.45881209D 11
KINETIC ERG	2.87959233D 10	1.04353376D 07	4.17979231D 07	1.66313850D 10	1.20458129D 10	6.64920946D 07
TOTAL ERG	2.86034983D 11	4.59985885D 09	6.80798138D 09	1.66334618D 10	1.20459801D 10	2.45947701D 11
VOL AVG RHO	2.03454375D 00	3.64682651D-02	2.06759303D-02	1.00000587D 00	7.80001307D 00	7.63411664D-02
VOL AVG PRE	1.47749128D 08	2.95986958D 08	2.96870946D 08	2.39804116D 08	1.23377163D 08	5.31106646D 07
VOL AVG GAM	8.40771581D-01	1.66670000D 00	2.00000000D 00	5.00000000D-01	5.00000000D-01	1.40000000D 00
VOL AVG ENT	5.34778532D 10	7.38122794D 10	6.94444444D 11	1.00000107D 11	3.58057422D 10	1.94601532D 09
VOL AVG RHOC	2.00624487D 00	0.00000000D 00	0.00000000D 00	1.00000000D 00	7.80000000D 00	0.00000000D 00
LAYER VOLUME	5.02654825D 03	1.03375117D 01	2.27916661D 01	2.12056259D 03	1.92101590D 03	1.85184057D 03
LAYER MASS	1.02267323D 04	3.76991118D-01	4.71238888D-01	2.12057504D 03	7.96393738D 03	1.41371669D 02

AFTER STEP NO. 800 DT = 0.28820594D-05 THE TIME IS 0.28716369D-02

I	POSITION	VELOCITY	DENSITY	PRESSURE	ENERGY	AVG PRESS	AVG VELOC	CELL VOLUME	ENTROPY	THFRAC	GAMMA
1	1.0000D-20	0.0000D 00	2.1399D 68	2.1399D 68	2.1399D 68	2.1399D 68	0.0000D 00	2.1399D 68	2.1399D 68	**********	**********
2	1.3503D 00	2.0351D 03	7.3123D-03	2.0331D 07	3.0510D 07	2.0464D 07	2.0363D 03	5.7284D 00	7.3812D 10	0.9995	1.6667
3	2.7003D 00	4.0375D 03	7.3153D-03	2.0344D 07	3.0563D 07	2.0477D 07	4.0426D 03	1.7178D 01	7.3812D 10	0.9984	1.6667
4	4.0489D 00	6.0379D 03	7.3241D-03	2.0385D 07	3.0684D 07	2.0518D 07	6.0450D 03	2.8596D 01	7.3812D 10	0.9965	1.6667
5	5.3700D 00	7.4327D 03	5.4245D-03	2.0434D 07	2.0563D 07	2.0567D 07	7.4441D 03	3.9093D 01	6.9444D 11	0.9937	2.0000
6	6.6350D 00	8.8556D 03	5.4327D-03	2.0496D 07	2.0683D 07	2.0630D 07	8.8704D 03	4.7707D 01	6.9444D 11	0.9910	2.0000
7	6.7844D 00	8.6606D 03	1.0000D 00	2.1376D 07	3.8343D 07	2.1514D 07	8.6744D 03	6.2971D 00	1.0000D 11	0.0000	0.5000
8	7.2176D 00	8.1405D 03	1.0000D 00	2.4395D 07	3.5217D 07	2.4548D 07	8.1519D 03	1.9059D 01	1.0000D 11	0.0000	0.5000
9	7.8983D 00	7.4388D 03	1.0000D 00	2.9181D 07	3.0217D 07	2.9353D 07	7.4474D 03	3.2323D 01	1.0000D 11	0.0000	0.5000
10	8.7841D 00	6.6885D 03	1.0000D 00	3.4289D 07	2.4807D 07	3.4473D 07	6.6946D 03	4.6426D 01	1.0000D 11	0.0000	0.5000
11	9.8387D 00	5.9714D 03	1.0000D 00	3.8837D 07	1.9906D 07	3.9025D 07	5.9757D 03	6.1701D 01	1.0000D 11	0.0000	0.5000
12	1.1036D 01	5.3237D 03	1.0000D 00	4.2524D 07	1.5843D 07	4.2710D 07	5.3266D 03	7.8484D 01	1.0000D 11	0.0000	0.5000
13	1.2357D 01	4.7543D 03	1.0000D 00	4.5373D 07	1.2615D 07	4.5553D 07	4.7564D 03	9.7110D 01	1.0000D 11	0.0000	0.5000
14	1.3792D 01	4.2595D 03	1.0000D 00	4.7522D 07	1.0095D 07	4.7693D 07	4.2609D 03	1.1791D 02	1.0000D 11	0.0000	0.5000
15	1.5336D 01	3.8308D 03	1.0000D 00	4.9122D 07	8.1358D 06	4.9283D 07	3.8318D 03	1.4123D 02	1.0000D 11	0.0000	0.5000
16	1.6984D 01	3.4589D 03	1.0000D 00	5.0303D 07	6.6081D 06	5.0454D 07	3.4596D 03	1.6744D 02	1.0000D 11	0.0000	0.5000
17	1.8738D 01	3.1353D 03	1.0000D 00	5.1169D 07	5.4093D 06	5.1309D 07	3.1357D 03	1.9675D 02	1.0000D 11	0.0000	0.5000
18	2.0596D 01	2.8524D 03	1.0000D 00	5.1797D 07	4.4616D 06	5.1927D 07	2.8527D 03	2.2962D 02	1.0000D 11	0.0000	0.5000
19	2.2560D 01	2.6040D 03	1.0000D 00	5.2244D 07	3.7062D 06	5.2365D 07	2.6042D 03	2.6634D 02	1.0000D 11	0.0000	0.5000
20	2.4633D 01	2.3849D 03	1.0000D 00	5.2554D 07	3.0992D 06	5.2666D 07	2.3851D 03	3.0725D 02	1.0000D 11	0.0000	0.5000
21	2.6815D 01	2.1909D 03	1.0000D 00	5.2759D 07	2.6078D 06	5.2863D 07	2.1909D 03	3.5268D 02	1.0000D 11	0.0000	0.5000
22	2.7314D 01	2.1508D 03	7.8000D 00	5.2929D 07	1.8376D 07	5.3023D 07	2.1509D 03	8.4926D 01	3.5806D 10	0.0000	0.5000
23	2.8223D 01	2.0816D 03	7.8000D 00	5.3191D 07	1.7456D 07	5.3269D 07	2.0816D 03	1.5853D 02	3.5806D 10	0.0000	0.5000
24	2.9391D 01	1.9988D 03	7.8000D 00	5.3482D 07	1.6220D 07	5.3538D 07	1.9988D 03	2.1153D 02	3.5806D 10	0.0000	0.5000
25	3.0765D 01	1.9095D 03	7.8000D 00	5.3712D 07	1.4878D 07	5.3741D 07	1.9095D 03	2.5961D 02	3.5806D 10	0.0000	0.5000
26	3.2311D 01	1.8181D 03	7.8000D 00	5.3835D 07	1.3532D 07	5.3837D 07	1.8181D 03	3.0642D 02	3.5806D 10	0.0000	0.5000
27	3.3978D 01	1.5259D 03	7.7104D-02	5.3834D 07	1.3469D 08	5.3822D 07	1.5382D 03	3.4715D 02	1.9460D 09	0.9992	1.4000
28	3.5585D 01	8.7307D 02	7.8360D-02	5.5066D 07	1.3772D 08	5.5030D 07	9.0361D 02	3.5120D 02	1.9460D 09	0.9996	1.4000
29	3.7107D 01	-4.8515D 01	8.1360D-02	5.8039D 07	1.4511D 08	5.7976D 07	-2.1653D 01	3.4752D 02	1.9460D 09	0.9999	1.4000
30	3.8563D 01	-5.9988D 02	8.3880D-02	6.0572D 07	1.5144D 08	6.0527D 07	-5.9804D 02	3.4607D 02	1.9460D 09	0.9999	1.4000
31	4.0000D 01	0.0000D 00	8.3961D-02	6.0654D 07	1.5164D 08	6.0699D 07	0.0000D 00	3.5471D 02	1.9460D 09	1.0000	1.4000

TIMINGS AT CYCLE 801 TIME = 2.8716D-03

REZONE	TIMESTEP	CELL PRINT	LAYER PRNT	GRAPHICS	CHEMISTRY	DIFFUSION	CONDUCTION	ADINC
0.0000D 00	4.0977D-01	2.2085D 00	5.3901D-01	0.0000D 00	0.0000D 00	0.0000D 00	0.0000D 00	1.0032D 01

ADINC FREQUENCY COUNTERS (SINCE LAST CHECK) AT CYCLE 801
NO. CALLS = 800 NO. TIMESTEPS = 50 TOTAL NO. ITERATIONS = 200

LAYER BOUNDARY	INTER 1	INTER 2	INTER 3	INTER 4	INTER 5	INTER 6
INTERFACE POSITION	1.00000000D-20	4.04892092D 00	6.63499148D 00	2.68146032D 01	3.23113425D 01	4.00000000D 01
INTERFACE VELOCITY	0.00000000D 00	6.03793689D 03	8.85563296D 03	2.19085622D 03	1.81814674D 03	0.00000000D 00
INTERFACE AREA	6.28318531D-20	2.54401204D 01	4.16888810D 01	1.68481121D 02	2.03018152D 02	2.51327412D 02

	TOTALS	SHELL 1	SHELL 2	SHELL 3	SHELL 4	SHELL 5
THERMAL ERG	2.55034737D 11	1.57323394D 09	1.77664010D 09	1.76714142D 04	1.04563797D 04	2.51684835D 11
KINETIC ERG	3.09854407D 10	3.98742054D 06	1.39672346D 07	1.51310402D 10	1.57675554D 10	6.88905056D 07
TOTAL ERG	2.86020178D 11	1.57722137D 09	1.79060734D 09	1.51310578D 10	1.57676658D 10	2.51753726D 11
VOL AVG RHO	2.03454375D 00	7.31985802D-03	5.42900910D-03	1.00000025D 00	7.80000224D 00	8.09385784D-02
VOL AVG PRE	5.23312960D 07	2.03655106D 07	2.04681645D 07	4.94515506D 07	5.35550531D 07	5.76381756D 07
VOL AVG GAM	8.50593788D-01	1.66670000D 00	2.00000000D 00	5.00000000D-01	5.00000000D-01	1.40000000D 00
VOL AVG ENT	6.28849805D 10	7.38122794D 10	6.94444444D 11	1.00000107D 11	3.58057422D 10	1.94601532D 09
VOL AVG RHOC	2.00624944D 00	0.00000000D 00	0.00000000D 00	1.00000000D 00	7.80000000D 00	0.00000000D 00
LAYER VOLUME	5.02654825D 03	5.15025178D 01	8.68001672D 01	2.12057452D 03	1.02101732D 03	1.74665372D 03
LAYER MASS	1.02267323D 04	3.76991118D-01	4.71238898D-01	2.12057504D 03	7.96393738D 03	1.41371669D 02

AFTER STEP NO. 900 DT = 0.29993926D-05 THE TIME IS 0.31635044D-02

I	POSITION	VELOCITY	DENSITY	PRESSURE	ENERGY	AVG PRESS	AVG VELOC	CELL VOLUME	ENTROPY	THERAC	GAMMA
1	1.0000D-20	0.0000D 00	2.1399D 68	2.1399D 68	2.1399D 68	2.1399D 68	0.0000D 00	2.1399D 68	2.1399D 68	**********	**********
2	1.8595D 00	1.5833D 03	3.8559D-03	6.9972D 06	1.0500D 07	7.0229D 06	1.5060D 03	1.0863D 01	7.3812D 10	0.9996	1.6667
3	3.7168D 00	3.0065D 03	3.8621D-03	7.0160D 06	1.0537D 07	7.0417D 06	3.0113D 03	3.2538D 01	7.3812D 10	0.9987	1.6667
4	5.5711D 00	4.5105D 03	3.8711D-03	7.0432D 06	1.0596D 07	7.0690D 06	4.5158D 03	5.4104D 01	7.3812D 10	0.9970	1.6667
5	7.2242D 00	5.4544D 03	3.1911D-03	7.0714D 06	7.1128D 06	7.0974D 06	5.4634D 03	6.6454D 01	6.9444D 11	0.9942	2.0000
6	8.8314D 00	6.4292D 03	3.1973D-03	7.0989D 06	7.1571D 06	7.1248D 06	6.4375D 03	8.1664D 01	6.9444D 11	0.9919	2.0000
7	8.9441D 00	6.3482D 03	1.0000D 00	7.4601D 06	2.0406D 07	7.4873D 06	6.3562D 03	6.2971D 00	1.0000D 11	0.0000	0.5000
8	9.2771D 00	6.1213D 03	1.0000D 00	8.7688D 06	1.9420D 07	8.8005D 06	6.1276D 03	1.9059D 01	1.0000D 11	0.0000	0.5000
9	9.8160D 00	5.7642D 03	1.0000D 00	1.1109D 07	1.7686D 07	1.1148D 07	5.7906D 03	3.2323D 01	1.0000D 11	0.0000	0.5000
10	1.0542D 01	5.3859D 03	1.0000D 00	1.4067D 07	1.5557D 07	1.4114D 07	5.3912D 03	4.6426D 01	1.0000D 11	0.0000	0.5000
11	1.1436D 01	4.9649D 03	1.0000D 00	1.7262D 07	1.3348D 07	1.7317D 07	4.9694D 03	6.1701D 01	1.0000D 11	0.0000	0.5000
12	1.2480D 01	4.5493D 03	1.0000D 00	2.0425D 07	1.1272D 07	2.0485D 07	4.5529D 03	7.8484D 01	1.0000D 11	0.0000	0.5000
13	1.3663D 01	4.1556D 03	1.0000D 00	2.3407D 07	9.4331D 06	2.3472D 07	4.1585D 03	9.7110D 01	1.0000D 11	0.0000	0.5000
14	1.4973D 01	3.7918D 03	1.0000D 00	2.6148D 07	7.8620D 06	2.6215D 07	3.7942D 03	1.1791D 02	1.0000D 11	0.0000	0.5000
15	1.6406D 01	3.4606D 03	1.0000D 00	2.8637D 07	6.5473D 06	2.8706D 07	3.4627D 03	1.4123D 02	1.0000D 11	0.0000	0.5000
16	1.7957D 01	3.1618D 03	1.0000D 00	3.0890D 07	5.4597D 06	3.0959D 07	3.1635D 03	1.6740D 02	1.0000D 11	0.0000	0.5000
17	1.9623D 01	2.8932D 03	1.0000D 00	3.2933D 07	4.5649D 06	3.3003D 07	2.8947D 03	1.9675D 02	1.0000D 11	0.0000	0.5000
18	2.1405D 01	2.6524D 03	1.0000D 00	3.4795D 07	3.8298D 06	3.4865D 07	2.6537D 03	2.2962D 02	1.0000D 11	0.0000	0.5000
19	2.3301D 01	2.4366D 03	1.0000D 00	3.6501D 07	3.2256D 06	3.6570D 07	2.4376D 03	2.6634D 02	1.0000D 11	0.0000	0.5000
20	2.5313D 01	2.2429D 03	1.0000D 00	3.8075D 07	2.7278D 06	3.8143D 07	2.2438D 03	3.0725D 02	1.0000D 11	0.0000	0.5000
21	2.7441D 01	2.0690D 03	1.0000D 00	3.9535D 07	2.3165D 06	3.9603D 07	2.0699D 03	3.5268D 02	1.0000D 11	0.0000	0.5000
22	2.9729D 01	2.0328D 03	7.8000D 00	4.1404D 07	1.6401D 07	4.1470D 07	2.0336D 03	8.4926D 01	3.5806D 10	0.0000	0.5000
23	2.8818D 01	1.9701D 03	7.8000D 00	4.4646D 07	1.5615D 07	4.4710D 07	1.9708D 03	1.5853D 02	3.5806D 10	0.0000	0.5000
24	2.9964D 01	1.8947D 03	7.8000D 00	4.9231D 07	1.4582D 07	4.9292D 07	1.8955D 03	2.1153D 02	3.5806D 10	0.0000	0.5000
25	3.1312D 01	1.8131D 03	7.8000D 00	5.4556D 07	1.3392D 07	5.4606D 07	1.8138D 03	2.7961D 02	3.5806D 10	0.0000	0.5000
26	3.2833D 01	1.7292D 03	7.8000D 00	6.0301D 07	1.2221D 07	6.0352D 07	1.7298D 03	3.6642D 02	3.5806D 10	0.0000	0.5000
27	3.4300D 01	2.2085D 03	8.6521D-02	6.3259D 07	1.5832D 08	6.3307D 07	2.2321D 03	3.0936D 02	1.9460D 09	0.9989	1.4000
28	3.5711D 01	2.4687D 03	8.8685D-02	6.5484D 07	1.6396D 08	6.5513D 07	2.4610D 03	3.1031D 02	1.9460D 09	0.9985	1.4000
29	3.7114D 01	1.9751D 03	8.8056D-02	6.4835D 07	1.6231D 08	6.4797D 07	1.9397D 03	3.2109D 02	1.9460D 09	0.9987	1.4000
30	3.8552D 01	9.0584D 02	8.4947D-02	6.1653D 07	1.5423D 08	6.1572D 07	8.8771D 02	3.4172D 02	1.9460D 09	0.9994	1.4000
31	4.0000D 01	0.0000D 00	8.3321D-02	6.0067D 07	1.5003D 08	5.9939D 07	0.0000D 00	3.5744D 02	1.9460D 09	0.9999	1.4000

TIMINGS AT CYCLE 901 TIME = 3.1635D-03

REZONE	TIMESTEP	CELL PRINT	LAYER PRNT	GRAPHICS	CHEMISTRY	DIFFUSION	CONDUCTION	ADINC
0.0000D 00	4.6090D-01	2.3379D 00	5.7078D-01	0.0000D 00	0.0000D 00	0.0000D 00	0.0000D 00	1.1337D 01

ADINC FREQUENCY COUNTERS (SINCE LAST CHECK) AT CYCLE 901
NO. CALLS = 900 NO. TIMESTEPS = 50 TOTAL NO. ITERATIONS = 165

LAYER BOUNDARY	INTER 1	INTER 2	INTER 3	INTER 4	INTER 5	INTER 6
INTERFACE POSITION	1.0000000D-20	5.57105529D 00	8.83135931D 00	2.74467149D 01	3.28327998D 01	4.00000000D 01
INTERFACE VELOCITY	0.0000000D 00	4.51001048D 03	6.42923770D 03	2.06895288D 03	1.72916790D 03	0.00000000D 00
INTERFACE AREA	6.28318531D-20	3.50039727D 01	5.50890671D 01	1.72415097D 02	2.06294565D 02	2.51327412D 02

	TOTALS	SHELL 1	SHELL 2	SHELL 3	SHELL 4	SHELL 5
THERMAL ERG	2.601380300D 11	1.027985270 09	1.045386520 09	5.412329850 03	1.031367830 04	2.580646420 11
KINETIC ERG	2.589020290D 10	2.217906600 06	7.472620820 06	1.147420050 10	1.416773460 10	2.385773110 08
TOTAL ERG	2.860282330 11	1.030293170 09	1.052859140 09	1.147420600 10	1.416774490 10	2.583032190 11
VOL AVG RHO	2.034543750 00	3.866395790-03	3.194462910-03	1.000000110 00	7.800002190 00	8.620569790-02
VOL AVG PRE	4.514071890 07	7.028983700 06	7.086529740 06	3.220744870 07	5.254278700 07	6.294512240 07
VOL AVG GAM	8.602821090-01	1.666700000 00	2.000000000 00	5.000000000-01	5.000000000-01	1.400000000 00
VOL AVG ENT	7.190759710 10	7.381227940 10	6.944444440 11	1.000001070 11	3.580574220 10	1.946015320 09
VOL AVG RHOC	2.006249510 00	0.000000000 00	0.000000000 00	1.000000000 00	7.800000000 00	0.000000000 00
LAYER VOLUME	5.026548250 03	9.750453370 01	1.475174110 02	2.120574810 03	1.021017330 03	1.639934170 03
LAYER MASS	1.022673230 04	3.769911180-01	4.712388980-01	2.120575040 03	7.963937380 03	1.413716690 02

AFTER STEP NO. 1000 DT = 0.33149137D-05 THE TIME IS 0.34768624D-02

I	POSITION	VELOCITY	DENSITY	PRESSURE	ENERGY	AVG PRESS	AVG VELOC	CELL VOLUME	ENTROPY	THERAC	GAMMA
1	1.0000D-20	0.0000D 00	2.1399D 68	2.1399D 68	2.1399D 68	2.1399D 68	0.0000D 00	2.1399D 68	2.1399D 68	**********	**********
2	2.2743D 00	1.1727D 03	2.5777D-03	3.5764D 06	5.3660D 06	3.5856D 06	1.1744D 03	1.4250D 01	7.3812D 10	0.9997	1.6667
3	4.5460D 00	2.3252D 03	2.5816D-03	3.5854D 06	5.3834D 06	3.5945D 06	2.3285D 03	4.8676D 01	7.3812D 10	0.9990	1.6667
4	6.8139D 00	3.4785D 03	2.5877D-03	3.5994D 06	5.4114D 06	3.6086D 06	3.4834D 03	8.0037D 01	7.3812D 10	0.9977	1.6667
5	8.7181D 00	4.1584D 03	2.2823D-03	3.6172D 06	5.6345D 06	3.6264D 06	4.1640D 03	9.2015D 01	6.9444E 11	0.9952	2.0000
6	1.0586D 01	4.8612D 03	2.2875D-03	3.6338D 06	3.6578D 06	3.6430D 06	4.8680D 03	1.1330D 02	6.9444D 11	0.9935	2.0000
7	1.0681D 01	4.8183D 03	1.0000D 00	3.8567D 06	1.1711D 07	3.8660D 06	4.8249D 03	6.2071D 00	1.0000D 11	0.0000	0.5000
8	1.0961D 01	4.6951D 03	1.0000D 00	4.6824D 06	1.1309D 07	4.6920D 06	4.7014D 03	1.0659D 01	1.0000D 11	0.0000	0.5000
9	1.1421D 01	4.5061D 03	1.0000D 00	6.2336D 06	1.0574D 07	6.2436D 06	4.5119D 03	3.2323D 01	1.0000D 11	0.0000	0.5000
10	1.2050D 01	4.2706D 03	1.0000D 00	8.3449D 06	9.6148D 06	8.3549D 06	4.2758D 03	4.6426D 01	1.0000D 11	0.0000	0.5000
11	1.2839D 01	4.0481D 03	1.0000D 00	1.0833D 07	8.5499D 06	1.0842D 07	4.0128D 03	6.1701D 01	1.0000D 11	0.0000	0.5000
12	1.3778D 01	3.7350D 03	1.0000D 00	1.3534D 07	7.4759D 06	1.3541D 07	3.7392D 03	7.8484D 01	1.0000D 11	0.0000	0.5000
13	1.4857D 01	3.4636D 03	1.0000D 00	1.6322D 07	6.4592D 06	1.6326D 07	3.4673D 03	9.7110D 01	1.0000D 11	0.0000	0.5000
14	1.6071D 01	3.2021D 03	1.0000D 00	1.9112D 07	5.5369D 06	1.9111D 07	3.2053D 03	1.1791D 02	1.0000D 11	0.0000	0.5000
15	1.7414D 01	2.9552D 03	1.0000D 00	2.1850D 07	4.7238D 06	2.1844D 07	2.9580D 03	1.4123D 02	1.0000D 11	0.0000	0.5000
16	1.8882D 01	2.7254D 03	1.0000D 00	2.4590D 07	4.0204D 06	2.4496D 07	2.7279D 03	1.6740D 02	1.0000D 11	0.0000	0.5000
17	2.0473D 01	2.5135D 03	1.0000D 00	2.7271D 07	3.4196D 06	2.7053D 07	2.5158D 03	1.9675D 02	1.0000D 11	0.0000	0.5000
18	2.2186D 01	2.3194D 03	1.0000D 00	2.9535D 07	2.9103D 06	2.9511D 07	2.3214D 03	2.2962D 02	1.0000D 11	0.0000	0.5000
19	2.4021D 01	2.1423D 03	1.0000D 00	3.1903D 07	2.4805D 06	3.1871D 07	2.1441D 03	2.6634D 02	1.0000D 11	0.0000	0.5000
20	2.5977D 01	1.9810D 03	1.0000D 00	3.4177D 07	2.1186D 06	3.4138D 07	1.9826D 03	3.0725D 02	1.0000D 11	0.0000	0.5000
21	2.8055D 01	1.8342D 03	1.0000D 00	3.6363D 07	1.8141D 06	3.6317D 07	1.8357D 03	3.5268D 02	1.0000D 11	0.0000	0.5000
22	2.8532D 01	1.8035D 03	7.8000D 00	3.9244D 07	1.2901D 07	3.9188D 07	1.8050D 03	8.4926D 01	3.5806D 10	0.0000	0.5000
23	2.9403D 01	1.7501D 03	7.8000D 00	4.4282D 07	1.2307D 07	4.4208D 07	1.7515D 03	1.5853D 02	3.5806D 10	0.0000	0.5000
24	3.0527D 01	1.6857D 03	7.8000D 00	5.1481D 07	1.1501D 07	5.1382D 07	1.6877D 03	2.1153D 02	3.5806D 10	0.0000	0.5000
25	3.1852D 01	1.6156D 03	7.8000D 00	5.9933D 07	1.0616D 07	5.9803D 07	1.6168D 03	2.5961D 02	3.5806D 10	0.0000	0.5000
26	3.3348D 01	1.5431D 03	7.8000D 00	6.9192D 07	9.7176D 06	6.9029D 07	1.5443D 03	3.0642D 02	3.5806D 10	0.0000	0.5000
27	3.4642D 01	1.4565D 01	9.6785D-02	7.4498D 07	1.8508D 08	7.3827D 07	-9.0629D 00	2.7655D 02	1.9460D 09	0.9997	1.4000
28	3.5956D 01	-4.5439D 02	9.4494D-02	7.1567D 07	1.7892D 08	7.1510D 07	-4.9978D 02	2.9124D 02	1.9460D 09	1.0000	1.4000
29	3.7308D 01	-4.0617D 01	9.0819D-02	6.7701D 07	1.6926D 08	6.7746D 07	-5.5791D 01	3.1133D 02	1.9460D 09	1.0000	1.4000
30	3.8665D 01	1.7510D 02	8.9643D-02	6.6476D 07	1.6619D 08	6.6501D 07	1.8254D 02	3.2382D 02	1.9460D 09	1.0000	1.4000
31	4.0000D 01	0.0000D 00	9.0267D-02	6.7125D 07	1.6781D 08	6.7197D 07	0.0000D 00	3.2094D 02	1.9460D 09	1.0000	1.4000

TIMINGS AT CYCLE 1001 TIME = 3.4769D-03

REZONE	TIMESTEP	CELL PRINT	LAYER PRNT	GRAPHICS	CHEMISTRY	DIFFUSION	CONDUCTION	ADINC
0.0000D 00	5.1205D-01	2.4673D 00	6.0254D-01	0.0000D 00	0.0000D 00	0.0000D 00	0.0000D 00	1.2478D 01

ADINC FREQUENCY COUNTERS (SINCE LAST CHECK) AT CYCLE 1001
NO. CALLS = 1000 NO. TIMESTEPS = 50 TOTAL NO. ITERATIONS = 150

LAYER BOUNDARY	INTER 1	INTER 2	INTER 3	INTER 4	INTER 5	INTER 6
INTERFACE POSITION	1.0000D-20	6.8139D 00	1.0586D 01	2.8054D 01	3.3348D 01	4.0000D 01
INTERFACE VELOCITY	0.0000D 00	3.4784D 03	4.8612D 03	1.8324D 03	1.5431D 03	0.0000D 00
INTERFACE AREA	6.2831D-20	4.2813D 01	6.6515D 01	1.7627D 02	2.0052D 02	2.5132D 02

	TOTALS	SHELL 1	SHELL 2	SHELL 3	SHELL 4	SHELL 5
THERMAL ERG	2.6668D 11	7.8590D 08	7.4781D 08	3.5455D 03	1.3676D 04	2.6515D 11
KINETIC ERG	1.9342D 10	1.3225D 00	4.3196D 00	8.1044D 09	1.1213D 10	1.8837D 07
TOTAL ERG	2.8602D 11	7.8722D 08	7.5213D 08	8.1044D 09	1.1213D 10	2.6517D 11
VOL AVG RHO	2.0345D 00	2.5846D-03	2.2851D-03	1.0000D 00	7.8000D 00	9.2264D-02
VOL AVG PRE	4.4310D 07	3.5921D 06	3.6263D 06	2.7063D 07	5.6809D 07	6.9190D 07
VOL AVG GAM	8.6985D-01	1.6667D 00	2.0000D 00	5.0000D-01	5.0000D-01	1.4000D 00
VOL AVG ENT	6.6866D 10	7.3612D 10	6.9444D 10	1.0000D 11	3.5806D 10	1.9460D 09
VOL AVG PHOC	2.0062D 00	0.0000D 00	0.0000D 00	1.0000D 00	7.8000D 00	0.0000D 00
LAYER VOLUME	5.0265D 03	1.4586D 02	2.0622D 02	2.1206D 03	1.0210D 03	1.5329D 03
LAYER MASS	1.0227D 04	3.7699D-01	4.7124D-01	2.1206D 03	7.9639D 03	1.4137D 02

Distribution List

1. Oak Ridge National Laboratory
   P.O. Box X
   Oak Ridge, Tennessee 37830

   Attn: G. Bateman
   C. Beasley
   R. Dory
   C. Crume
   R. Ranie
   J. Rome

2. Department of Energy
   Washington, D.C. 20545

   Attn: B. Miller (3 copies)
   W. Sadowski
   A. Sleeper
   G. Ingraham
   R. Blanken
   J. Pearlman
   S. Kahalas
   G. Canavan

3. Lawrence Livermore Laboratory
   University of California
   Livermore, California 94551

   Attn: J. Killeen
   B. McNamara
   D. Fuss
   D. Anderson
   J. Byers
   P. Crowley
   B. Langdon
   G. Zimmerman
   B. Lasinski
   J. Nucholls
   J. Lindl
   W. Mead

4. Massachusetts Institute of Technology
   Lincoln Laboratory
   244 Wood Street
   Lexington, Massachusetts 02173

   Attn: A Bers (E.E.)

5. U.C. L.A.
   Los Angeles, California 90024

   Attn: J. Dawson
   B. Fried
   Y.C. Lee

6. Princeton University
   Plasma Physics Laboratory
   Princeton, New Jersey 08540

   Attn: R. Grimm
   H. Fallon
   J. M. Greene
   J. Johnson
   H. Okuda
   P. Rutherford
   R. Mills
   D. Jassby
   R. Kulsrud

7. Los Alamos Scientific Laboratory
P. O. Box 1663
Los Alamos, New Mexico 87344

Attn: C. Nielson, E. Lindman, D. Forslund, J. Kindell, H. R. Lewis, B. Marder, B. Godfrey, J. U. Brackbill, T. Hirt, R. Mason

8. University of Texas
Austin, Texas 78712

Attn: L. Sloan, F. Hinton, D. Ross

9. University of California
Berkeley, California 94720

Attn: Prof. A. Kaufman
Prof. C. K. Birdsall

10. Bell Telephone Laboratories
Shippany, New Jersey 07981

Attn: A. Hasegawa, S. Buchsbaum

11. General Atomic Co.
P.O. Box 81608
San Diego, California 92138

Att: T. Ohkawa, G. Guest, J. Rawls, D. Dobrott, J. Helton

12. New York University
Courant Institute of Math. Sci.
251 Mercer Street
New York, N.Y. 10012

Attn: W. Grossman, D. Stevens, A. Harten, A. Jameson, J. Tataronis, P. D. Lax, K. Morowitz, E. Turkel, F. Tappert, G. Morikawa, H. Grad

13. University of Maryland
College Park, Maryland 20742

Attn: P.C. Liewer, K. Papadopoulos

14. Stevens Institute of Technology
Hoboken, New Jersey 07030

Attn: Georg Schmidt
R. Rosen

15. College of William and Mary
Williamsburg, Virginia 23185

Attn: S. P. Gary
Fred Crownfield

16. Culham Laboratory
Abingdon, Berkshire, England

Attn: Keith Roberts
Jes Christiansen
A. Sykes
M. Hughes
J. A. Wesson
M. Watkins

17. Sandia Laboratory
Albuquerque, New Mexico 87115

Attn: Thomas Wright
J. Freeman

18. University of Rochester
Rochester, New York 14627

Attn: E. B. Goldman

19. Max Planck Institute fur Plasma Physics
8046 Garching bei Munchen
West Germany

Attn: D. Biskamp
W. Schneider
B. Greene
K. Von Hagenow
Chodura

20. Science Applications, Inc.
Laboratory for Applied Plasma Physics
Research Staff
La Jolla, California 92037

Attn: J. McBride
C. Wagner
H. Klein
N. Byrne

21. Association Euratom-CEA Serv La Fusion
Dept. of Physics du Plasma et de la
Fusion Controlee
Center d'Etudes Nucleaires
Boite Postale No. 6
92260 Fontenay-Aux-Rose
France

Attn: Dr. Tachon
Dr. Mercier
R. B. Paris

22. Department of Physics
Yale University
206 Elm St.
New Haven, Conn. 06520

Attn: I.B. Bernstein

23. Office of Naval Research
800 North Quincy St.
Arlington, Va. 22217

Attn: Stewart Brodsky
R. Cooper
M. Cooper
R. Lundegard

24. Naval Research Laboratory
Washington, D.C. 20375

Attn: Code 6700 (Tena Mason) - 25 copies
4200 (Al Bligh) - 25 copies
4201 (Doris Gossett)
4220 (Gary Flenner)
4220 (John Houston)
4221 (Doug Shannon)
5207.5 (A. Sills)
6180 (D. Indritz)
Code 4207 (J. McCaffrey)
6665 (G. Herling)
5565 (P. Ulrich)
6790 (I. Haber)
6700 (T. Coffey)
6020 (D. Book)
6790 (N.Winsor)
6030 (J. Karle
3 copies)
6020 (J. Boris)

25. Institute for Plasma Research
Stanford University
Stanford, Calif. 94305

Attn: Prof. Oscar Buneman
Prof. C. Barnes

26. Ecole Polytechnique Federale Lausanne
Lausanne, Switzerland

Attn: E. Wiebel
R. Gruber
K. Appert

27. Columbia University
Department of Mechanical Eng.
New York, N.Y. 10027

Attn: Prof. C.K. Chu
Prof. R. Gross

28. Science Applications, Inc.
122 Laveta, N.E.
Albuquerque, N.M. 87108

Attn: P. Roache

29. Ames Research Center
N.A.S.A.
Moffet Field, Calif. 94035

Attn: R. MacCormack (3 copies)

30. University of Iowa
Department of Physics and Astronomy
Iowa City, Iowa 52240

Attn: G. Knorr
G. Joyce

31. Tel Aviv University
Dept. of Physics and Astronomy
Ramat-Aviv, Israel

Attn: Dr. Sami Cuperman

32. National Science Foundation
Washington, D.C. 20550

Attn: E.C.Creutz
R. Sinclair

33. University of Wisconsin
Madison, Wisconsin 53706

Attn: Prof. K. Symon
R. Conn

34. Institute for Advanced Study
Olden Lane
Princeton, N.J. 08540

Attn: M. Rosenbluth

35. Japan Atomic Energy Research Institute
Tokai-Mura
Ibaraki-Ken, Japan

Attn: N. Fujisawa (5 copies)

36. Jaycor Company
Del Mar, California 02014

Attn: J. Young
R. Chan

37. Australian National University
Canberra A.C.T. Australia

Attn: J.D. Strachan
R. L. Dewar

38. Kurchatov Institute
Moscow, U.S.S.R

Attn: B.B. Kadomtsev
E.P. Velikov

39. U.S. Army Ballistic Research Labs
Aberdeen Proving Ground, Md. 21005

Attn: Zoltan Czaba
Douglas Kooker

40. Imperial College of Science and Technology
Department of Physics (Plasma Group)
London, SW7, England

Attn: D. Potter
R.S. Craxton

41. Dr. Leon Ettinger
Department of Physics
and Atmospheric Science
Drexel University
Philadelphia, Pa. 19104

42. S. R. Goldman
c/o Jaycor
1401 Camino Del Mar
Del Mar, Calif. 92014

Att: N. Krall
R. Chan

43. Yu. S. Sigov
Institute of Applied Mathematics
of the USSR Academy of Sciences
Miussakaya Sg. 4
Moscow A-47
USSR

44. Director
Defense Advanced Rsch. Proj. Agency
Architect Building
1400 Wilson Blvd.
Arlington, Va. 22209
Attn: Strategic Tech. Office (3 copies)
Col. W. Whittaker

45. Defense Documentation Center
Cameron Station
Alexandria, Va. 22314
Attn: TC (12 copies)

45. Director
Defense Nuclear Agency
Washington, D.C. 20305
Attn: RAAE (3 copies)

46. Director
Defense Nuclear Agency
Washington, D.C. 20305
Attn: STSI Archives

7. Director
Defense Nuclear Agency
Washington, D. C. 20305
Attn: STTL Tech Library

48. Director
Defense Nuclear Agency
Washington, D. C. 20305
Attn: DDST (3 copies)

49. Commander
Field Command
Defense Nuclear Agency
Kirtland AFB, N.M. 87115
Attn: FCPR

50. Interservice Nuclear Weapons School
Kirtland AFB, N.M. 87115
Attn: Document Control

51. Chief
Livermore Division Fld. Command DNA
Lawrence Livermore Laboratory
P. O. Box 808
Livermore, Ca. 94550
Attn: FCPRL

52. OJCS/J-3
The Pentagon
Washington, D. C. 20301
Attn: J-3 OPS Anal. Br. Col. Underhill

53. Weapons Systems Evaluation Group
400 Army Navy Drive
Arlington, Va. 22202
Attn: Document Control

54. Manager
BMD Program Office
1300 Wilson Blvd.
Arlington, Va. 22209
Attn: Plans Division

55. Manager
BMD Program Office
1300 Wilson Blvd.
Arlington, Va. 22209
Attn: DACS-BMM

56. Commander
Harry Diamond Laboratories
2800 Powder Mill Rd.
Adelphi, Md. 29783
Attn: AMXDO-NP
Raine Gilbert

57. Commander
Trasana
White Sands Missle Range, N. M. 88002
Attn: R. E. Dekinder, Jr.

58. Director
U. S. Army Ballistic Research Labs.
Aberdeen Proving Ground, Md. 21005
Attn: AMXBR-CA, Franklin E. Niles (5 copies)

59. Commander
U. S. Army Material Command
5001 Eisenhower Avenue
Alexandria, Va. 22333
Attn: Director of Development

60. Commander
U.S. Army Nuclear Agency
Fort Bliss, Texas 79916
Attn: USANUA - W.J. Berberet

61. Chief Naval Research
Department of the Navy
Arlington, Va. 22217
Attn: Code 418 (3 copies)

62. AF Cambridge Rsch. Labs., AFSC
L.G. Hanscom Field
Bedford, Ma. 01730

63. AF Cambridge Rsch. Labs. AFSC
L. G. Hanscom Field
Bedford, Ma. 01730
Attn: OPR Alva T. Stair

64. AF Weapons Laboratory, AFDC
Kirtland AFB, N.M. 87117
Attn: CA Arthur H. Guanther

65. AF Weapons Laboratory, AFSC
Kirtland AFB, N.M. 87117
Attn: Lt. Mark A. Fry

66. AFTAC
Patrick AFB, Fla. 32925
Attn: TF/Capt. Wiley

67. 541ES
Offut AFB, N.M. 68113
Attn: ROPO Lt. Alan B. Merrill

68. Los Alamos Scientific Laboratory
P.O. Box 1663
Los Alamos, N. M. 87544
Attn: DOC CON for Eric Jones
DOC CON for Martin Tierney J-10
DOC CON for John Zinn

69. EG&G, Inc.
Los Alamos Division
P.O. Box 809
Los Alamos, N.M. 85544
Attn: James R. Breedlove

70. ESL, Inc.
495 Java Drive
Sunnyvale, Ca. 94086
Attn: James Marshall

71. General Electric Company
Space Division
Valley Forge Space Center
P.O. Box 85555
Philadelphia, Pa. 19101
Attn: M.H. Bortner, Space Sci. Lab.

72. General Electric Company
Space Division
Valley Forge Space Center
P. O. Box 85555
Philadelphia, Pa. 19101
Attn: M. H. Bortner, Space Sci. Lab.

73. General Electric Company
Tempe-Center for Advanced Studies
816 State Street (P.O. Drawer QQ)
Santa Barbara, Ca. 93102
Attn: DASIAC

74. General Electric Company
Tempo-Center for Advanced Studies
816 State Street (P.O. Drawer QQ)
Santa Barbara, Cal.
Attn: Tom Barrett
Warren S. Knapp
William McNamara

75. General Research Corportation
P.O. Box 3587
Santa Barbara, Cal. 93105
Attn: John Ise, Jr.

76. MIT Lincoln Laboratory
P.O. Box 73
Lexington, Ma. 02173
Attn: LIB A-082 for David M. Towle

77. Mission Research Corporation
735 State Street
Santa Barbara, Cal. 93101
Attn: F. Fajen
R. Stettner
Conrad L. Longmire
D. Sappenfield
Dave Sowle

78. Physical Dynamics, Inc.
P.O. Box 1069
Berkeley, Cal. 94701
Attn: Joseph B. Workman

79. R. and D. Associates
P. O. Box 3580
Santa Monica, Ca. 90402
Attn: Forest Gilmore
Robert E. Lelevier
Alan Kukl

80. Science Applications, Inc.
P.O. Box 2351
La Jolla, Ca. 92038
Attn: D. Sachs
Daniel A. Hamlin

81. Stanford Research Institute
333 Ravenswood Avenue
Menlo Park, Ca. 94025
Attn: Walter G. Chestnut

82. Stanford Research Institute
305 Wynn Drive, N.W.
Huntsville, Ala. 35805
Attn: Dale H. Davis

83. Visidyne, Inc.
19 Third Avenue
North West Industrial Park
Burlington, Ma 01803
Attn: J.W. Carpenter

84 Robert J. Gelinas (Dr.)
Science Applications, Inc.
80 Mission Drive
Pleasanton, California 94566

85. Mr. Dan Hartley
Sandia Laboratories
Department 8350
Livermore, Cal. 94550

86. Dr. Joe Heimerl
Department of the Army
Aberdeen Proving Ground, Maryland 21005

87. Dr. E.J. Kansa
Theoretical Support
U.S. Bureau of Mines
4800 Forbes Ave
Pittsburgh, Pa. 15213

88. Dr. Douglas E. Kooker
Ignition and Combustion Branch
Propulsion Division
Department of the Army
Averdeen Proving Ground, Md. 21005

89. Prof. John H.S. Lee
McGill University
Mechanical Engineering Dept
817 Sherbrooke Street
Sherbrooke St W.,
Montreal, PQ Canada H3A 2K6

90. Dr. Harry McDonald
Scientific Research Associates, Inc.
Box 498
Glastonbury, Ct. 06033

91. Mr. A.C. McIntosh
Cranfield Institute of Technology
Cranfield Bedford MK OAL

92. Prof. Antoni K. Oppenheim
Department of Mechanical Engineering
University of California/Berkeley
Berkeley, California 94904

93. Dr. Harry Phillips
Health and Safety Executive
SMRE
Baxton
Derbys: SK 17 9Jn
England

94. Dr. William O. Adams
Department of Energy
Division of Basic Energy Sciences
Washington, D. C. 20545

95. Dr. John D. Anderson, Jr.
Department of Aerospace Engineering
University of Maryland
College Park, Md. 20742

96. Dr. Howard R. Baum
National Bureau of Standards
Washington, D.C. 20234

97. Dr. Arthur A. Boni
Science Applications, Inc.
P.O. Box 2351
La Jolla, California 92037

98. Roland Borghi
ONERA
29 Avenue de la Division Leclerc
92320 Chatillon-sours-Bagneaux
France

99. Mr. S. Candel
ONERA
29 Ave de la Division Leclerc
92390 Chatillon
France

100. Dr. Julius S. Chang
Lawrence Livermore Laboratory
P.O. Box 808 L-71
Livermore, Cal. 94550

101. Raymond Edelman
Science Application, Inc.
20335 Ventura Blvd
Suite 423
Woodland Hills, Cal. 91364

102. Dr. David Edelson
Bell Telephone Laboratories
600 Mountain Avenue
Murray Hill, New Jersey 07974

103. Dr. John Edwards
U.S. Department of the Interior
Bureau of Mines
Pittsburg Mining and Safety Research
4800 Forbes Ave
Pittsburgh, Pa. 15213

104. Dr. James C.T. Pool
Basic Energy Sciences
Department of Energy
20 Massachusetts Avenue, N.W.
Washington, D.C. 20545

105. Prof. Steven Pope
Massachusetts Institute of Technology
Department of Mechanical Engineering
Cambridge, Mass 02139

106. Prof. David T. Pratt
University of Michigan
Department of Mechnical Engineering
Ann Arbor, MI 48104

107. Dr. Ronald G. Rehm
National Bureau of Standards
Washington, D.C. 20234

108. Dr. Bill R. Sanders
Sandia Laboratories
East Avenue
Livermore, Ca. 94550

109. William A. Sirignano
Room D-207
Engineering Quad
Princeton University
Princeton, New Jersey 08540

110. Charles K. Westbrook
University of California
Lawrence Livermore Laboratory
PO Box 808
Livermore, California 94550

*U.S. GOVERNMENT PRINTING OFFICE: 1979 281-484/50

DEPARTMENT OF THE NAVY

NAVAL RESEARCH LABORATORY
Washington, D.C. 20375

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE, $300

POSTAGE AND FEES PAID
DEPARTMENT OF THE NAVY
DoD-316
THIRD CLASS MAIL

U.S.MAIL

NRL

THE NAVAL RESEARCH LABORATORY IS AN ACTIVITY OF THE OFFICE OF NAVAL RESEARCH